U.S. Fish & Wildlife Service

Chiricahua Leopard Frog (*Rana chiricahuensis*)

Final Recovery Plan

April 2007

CHIRICAHUA LEOPARD FROG
(*Rana chiricahuensis*)
RECOVERY PLAN

Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

CHIRICAHUA LEOPARD FROG
(Rana chiricahuensis)

RECOVERY PLAN

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Chiricahua Leopard Frog
Recovery Team,
including the Technical Subgroup,
Southeastern Arizona/Southwestern New Mexico Stakeholder Subgroup,
Mogollon Rim Stakeholder Subgroup, and
West-Central New Mexico Stakeholder Subgroup

Prepared for:
Southwest Region
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Albuquerque, New Mexico

Approved: _____ Date: March 14, 2007
Regional Director, Southwest Region
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Concur: _____ Date: 3-30-07
Director, Arizona Game and Fish Department

Concur: _____ Date: 4-13-07
Director, New Mexico De artment of Game and Fish

DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans are published by the U.S. Fish and Wildlife Service, and are sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director, or Director, as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citation of this document should read as follows:

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Additional copies may be obtained from:

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On-line: http://www.fws.gov/arizonaes and http://www.fws.gov/endangered/

PLAN PREPARATION

This recovery plan was developed by the Chiricahua Leopard Frog Recovery Team. The Team is composed of a Technical Subgroup and three Stakeholders Subgroups (West-Central New Mexico, Southeastern Arizona/Southwestern New Mexico, and Mogollon Rim). The Technical Subgroup provided expertise in amphibian biology, hydrology, forest management, captive care and amphibian diseases, and conservation biology. The Stakeholders Subgroups kept the process grounded in the logistical realities of on-the-ground implementation. All subgroup members had the opportunity to contribute to this recovery plan, and many took advantage of that opportunity over the 18 months of meetings and workshops that resulted in this document.

ACKNOWLEDGMENTS

The U.S. Fish and Wildlife Service thanks all recovery team subgroup members (see "LIST OF CONTACTS"), particularly the subgroup leaders or mediators: Mike Sredl and Randy Jennings (Co-leads for the Technical Subgroup), Anna Magoffin and Ron Bemis (Leaders/Mediators for the Southeastern Arizona/Southwestern New Mexico Stakeholders), Ben Brown (Leader for the West-Central New Mexico Stakeholders), and Cecelia Overby and Terry Myers (Leaders for the Mogollon Rim Stakeholders). Kevin Wright, Ross Humphreys, Doug Powers, and Jony Cockman served as liaisons between subgroups. We also thank our external liaisons: Cynthia Dale (White Mountain Apache Tribe), Stefanie White and Tianna Thompson (San Carlos Apache Tribe), and Eduardo Lopez and Rafaela Paredes (Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora – IMADES, currently known as CEDES - La Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora), as well as our internal liaisons: Jim Rorabaugh (also an editor on the plan), Melissa Kreutzian, Eileen Everett, Tracy (Scheffler) Melbihess, Marty Tuegel, Rawles Williams, and Patricia Zenone. Susi MacVean translated the Executive Summary into Spanish. Dennis Caldwell of the Southeastern Arizona/Southwestern New Mexico Stakeholders Subgroup provided the art for the recovery plan. Jim Rorabaugh provided several photographs, including the Chiricahua leopard frog image on the inside cover page.

EXECUTIVE SUMMARY

Current Status: The Chiricahua leopard frog is federally listed as threatened without critical habitat. The species' recovery priority number is 2C, which indicates a high degree of threat, a high potential for recovery, and a taxonomic classification as a species. A special rule exempts operation and maintenance of livestock tanks on non-Federal lands from the Section 9 take prohibitions of the Endangered Species Act. The species occurs at elevations of 3,281 to 8,890 feet in central and southeastern Arizona, west-central and southwestern New Mexico, and the sky islands and Sierra Madre Occidental of northeastern Sonora and western Chihuahua, Mexico. The range of the species is split into two disjunct parts - northern populations along the Mogollon Rim in Arizona east into the mountains of west-central New Mexico, and southern populations in southeastern Arizona, southwestern New Mexico, and Mexico. Genetic analysis suggests the northern populations may be an undescribed, distinct species.

Habitat Requirements and Limiting Factors: The Chiricahua leopard frog is an inhabitant of montane and river valley cienegas, springs, pools, cattle tanks, lakes, reservoirs, streams, and rivers. It is a habitat generalist that historically was found in a variety of aquatic habitat types, but is now limited to the comparatively few aquatic systems that support few or no non-native predators (e.g. American bullfrogs, fishes, and crayfishes). The species also requires permanent or semi-permanent pools for breeding, water characterized by low levels of contaminants and moderate pH, and may be excluded or exhibit periodic die-offs where a pathogenic chytridiomycete fungus is present. Threats to this species include predation by non-native organisms, especially American bullfrogs, fish, and crayfish; the fungal disease chytridiomycosis; drought; floods; degradation and loss of habitat as a result of water diversions and groundwater pumping, livestock management that degrades frog habitats, catastrophic wild fire (fire-prone upland habitats) resulting from a long history of fire suppression, mining, development, and other human activities; disruption of metapopulation dynamics; increased chance of extirpation or extinction resulting from small numbers of populations and individuals existing in dynamic environments; and environmental contamination such as runoff from mining operations and airborne contaminants from copper smelters. Loss of Chiricahua leopard frog populations fits a pattern of global amphibian decline, suggesting other regional or global causes of decline may be important as well, such as elevated ultra-violet radiation, pesticides or other contaminants, and climate change.

Recovery Goal: To recover and delist the Chiricahua leopard frog.

Recovery Strategy: The frog must reach a population level and have sufficient habitat to provide for the long-term persistence of metapopulations in each of eight recovery units (RUs) across the species' range. The strategy will involve reducing threats to existing populations; maintaining, restoring, and creating habitat that will be managed in the long-term; translocating frogs to establish, reestablish, or augment populations; building support for the recovery effort through outreach and education; monitoring; research to provide effective conservation and recovery; and application of research and monitoring through adaptive management. Management areas (MAs) are identified in each RU where we believe the potential for successful recovery actions is greatest.

Establishment and maintenance of at least two metapopulations in different drainages within each RU are integral to the recovery strategy. These metapopulations must exhibit long-term persistence and be protected from non-native predators, disease, habitat alteration, and other threats. As a buffer against disease, at least one additional robust, but isolated population should be established and maintained in each RU. A captive or actively-managed, genetically diverse refugium population may also be desirable for RUs in which extirpation of Chiricahua leopard frogs is likely in the near future. These refugia can serve as a source of animals for establishment and augmentation projects, for contingency planning in case of environmental or other disasters that reduce or eliminate populations, and to supply animals needed for research related to conservation.

Implementation of the recovery strategy will be conducted as a collaborative effort among technical experts, zoos and museums, agencies, and other participants and stakeholders. We envision regional working groups to implement recovery in RUs or MAs. Recovery and the status of the species will be tracked via monitoring and annual reporting through the working groups. Research recommended herein will provide the information needed to ensure the recovery strategy is as effective as possible. Working groups and the U.S. Fish and Wildlife Service will evaluate research results and revise or update this recovery plan as appropriate.

Recovery Criteria: The Chiricahua leopard frog will be considered for delisting when the following quantitative criteria are met in each RU:

1. At least two metapopulations located in different drainages (defined here as USGS 10-digit Hydrologic Units) plus at least one isolated and robust population in each RU exhibit long-term persistence and stability (even though local populations may go extinct in metapopulations) as demonstrated by a scientifically acceptable population monitoring program (see Appendix K for definitions of metapopulation, robust population, long-term persistence, and stability). Interpretation of monitoring results will take into account precipitation cycles of drought or wet periods and the effects of such cycles on population persistence.
2. Aquatic breeding habitats, including suitable, restored, and created habitats necessary for persistence of metapopulations and isolated populations identified in criterion 1, are protected and managed in accordance with the recommendations in this plan.
3. The additional habitat needed for population connectivity, recolonization, and dispersal is protected and managed for Chiricahua leopard frogs, in accordance with the recommendations in this plan.
4. Threats and causes of decline have been reduced or eliminated, and commitments of long-term management are in place in each RU such that the Chiricahua leopard frog is unlikely to need protection under the ESA in the foreseeable future.

Delisting by recovery unit or other subset of the species will not occur unless distinct population segments are subsequently designated by a rule-making process. Progress toward achieving recovery criteria will be measured via research, monitoring, and population and habitat viability analyses. In addition, regulatory mechanisms and land management commitments must be implemented to provide for adequate long-term protection of the Chiricahua leopard frog and its habitat. These commitments and mechanisms should address habitat maintenance and

protection, management of non-native predators, disease transmission, maintenance of metapopulation dynamics, and public outreach and education.

Actions Needed:

1. Protect remaining populations of Chiricahua leopard frogs.
2. Identify, protect, restore, or create as needed, currently unoccupied recovery sites in each RU necessary to support viable populations and metapopulations of Chiricahua leopard frogs.
3. Establish new or re-establish former populations at selected recovery sites.
4. Augment populations in MAs as needed to increase persistence.
5. Monitor Chiricahua leopard frog populations and their habitats; monitor implementation of the recovery plan.
6. Implement research needed to support recovery actions and adaptive management.
7. Develop and implement public outreach and broad-based community planning to promote public support, participation in, and understanding of recovery actions.
8. Develop cooperative conservation projects, such as Safe Harbor Agreements and Habitat Conservation Plans, with willing landowners to implement recovery on non-federal land.
9. Develop and amend land use plans, habitat management plans, and other plans as needed to implement recovery actions.
10. Work with Tribal partners to promote recovery on Tribal lands.
11. Work with Mexican partners to promote recovery in Mexico.
12. Practice adaptive management in which recovery tasks are revised by the U.S. Fish and Wildlife Service in coordination with the Recovery Team Subgroups as pertinent new information becomes available.

Total Cost of Recovery (minimum): $3,413,000

Costs, in thousands of dollars:

Year	Minimum Costs: ($000s)
2005	710
2006	739
2007	763
2008	637
2009	564
2010+	To be determined

Date of Recovery: If recovery actions are promptly and successfully implemented, and recovery criteria are met, we estimate that delisting could be initiated by 2035.

RESUMEN EJECUTIVO

Estado Actual: La rana de Chiricahua se incluye en la lista federal de especies amenazadas con la extinción, pero sin hábitat crítico. La prioridad de recuperación de esta especie es 2C, la cual indica un alto grado de amenaza, un alto potencial para su recuperación, y una clasificación taxonómica como especie. Un reglamento especial exenta la operación y el mantenimiento de tanques para el ganado en tierras no-federales de las prohibiciones de toma de la Sección 9 de la Ley de Especies en Peligro de Extinción. La especie ocurre de 3,281 a 8,890 pies de altura en Arizona central y sudeste; New México oeste-central y sudoeste; y en montañas aisladas y en la Sierra Madre Occidental del noreste de Sonora y del oeste de Chihuahua, México. La distribución de la especie ocurre en dos áreas disjuntas – las poblaciones norteñas a lo largo del Mogollon Rim en Arizona oriental y en las montañas de New México oeste-central; y las poblaciones sureñas en el sudeste de Arizona y sudoeste de New México y en México. El análisis genético sugiere que las poblaciones norteñas puedan ser una especie distinta, aún no descrita.

Requisitos del hábitat y factores limitantes: La rana de Chiricahua habita ciénegas de montaña y de valle, manantiales, estanques, tanques para el ganado, lagos, reservas de agua, arroyos y ríos. Es una especie generalista de hábitat que históricamente se encontraba en una variedad de hábitats acuáticos, pero ahora se limita a comparativamente pocos sistemas acuáticos que no sostienen, o sostienen a pocos, depredadores introducidos (especies alóctonas, e.g. *Rana catesbeiana*, peces, y cangrejo de río). La especie también requiere estanques permanentes o semi-permanentes para reproducirse, agua baja en contaminantes y de pH moderado, y puede ser excluida o puede mostrar episodios periódicos de mortandad si hay presentes hongos patógenos de quitridiomicete. Las amenazas para esta especie incluyen la depredación por especies alóctonas, especialmente la *Rana catesbeiana*, peces, y cangrejos de río; la enfermedad causada por hongos, quitridiomicosis; sequía; inundaciones; degradación y pérdida del hábitat debido a diversiones de agua y bombeo de agua subterránea, manejo del ganado que ha o continúa a degradar el hábitat de la rana, hábitats propensos al fuego debido a una larga historia de supresión del fuego, la actividad de minar, el desarrollo, y otras actividades humanas; la perturbación de la dinámica de metapoblaciones; un aumento en la probabilidad de la extirpación o de la extinción debido a pocas poblaciones e individuos que existen en ambientes dinámicos; y probablemente la contaminación del medio ambiente (tal como los residuos asociados con operaciones mineras y contaminantes aerotransportados asociados con los fundidores de cobre). La pérdida de poblaciones de la rana de Chiricahua cabe dentro del patrón del declive global de anfibios, lo cual sugiere que otras causas regionales o globales del declive puedan ser importantes también, por ejemplo la radiación ultravioleta elevada, plaguicidas, u otros contaminantes, y el cambio del clima.

Meta de la Recuperación: Recuperar a la rana de Chiricahua y excluirla de la lista de especies en peligro de extinción.

Estrategia de la Recuperación: La rana debe alcanzar un nivel de población y tener suficiente hábitat para asegurar la persistencia de metapoblaciones a largo plazo en cada una de ocho unidades de recuperación (UR). La estrategia incluirá la reducción de factores que amenazan a las poblaciones actuales; el mantenimiento, la restauración, y la creación de hábitat que será

manejado a largo plazo; el traslado de ranas para establecer, re-establecer o aumentar las poblaciones; el fomento del apoyo público para el esfuerzo de recuperación a través de la comunicación y la educación; el monitoreo; la investigación necesaria para la conservación y la recuperación eficaz; y la aplicación de la investigación y del monitoreo a través del manejo adaptativo. Areas de Manejo (AM) han sido identificadas en cada UR donde creemos tener el mayor potencial para lograr las acciones de recuperación.

El establecimiento y el mantenimiento de por lo menos dos metapoblaciones en diferentes drenajes dentro de cada UR son claves a la estrategia de la recuperación. Estas metapoblaciones deben exhibir persistencia a largo plazo y deben ser protegidas contra los depredadores introducidos, la enfermedad, la alteración del hábitat, y otras amenazas. Como amortiguador contra la enfermedad, por lo menos una población robusta adicional, pero aislada, debe ser establecida y mantenida en cada UR. Una poblacion refugio, cautiva o de manejo activo, y de genética diversa será deseable para URs donde la extirpación de las ranas de Chiricahua es probable en el futuro cercano. Estos refugios pueden servir como fuente de animales para proyectos de establecimiento y de aumento, como seguro contra los desastres ambientales u otros desastres que reducen o eliminan poblaciones, y para proveer animales necesarios para la investigación asociada con la conservación.

La puesta en práctica de la estrategia de recuperación será un esfuerzo de colaboración entre expertos técnicos, parques zoológicos y museos, agencias, y otros participantes y personas afectadas. Prevemos el uso de grupos técnicos de trabajo regionales para llevar a cabo la recuperación en URs o AMs. La recuperación y el estado de la especie serán supervisados a través del monitoreo y el reportaje anual por medio de los grupos de trabajo. La investigación recomendada en este documento proporcionará la información necesaria para asegurar que la estrategia de la recuperación sea la más eficaz posible. Los grupos de trabajo y el Servicio de Pesca y Vida Silvestre de Estados Unidos ("USFWS") evaluarán los resultados de la investigación y revisarán o pondrán al día este plan de recuperación como sea apropiado.

Criterios de la Recuperación: La rana de Chiricahua será considerada para exclusión de la lista de especies amenazadas con la extinción cuando se cumplan los siguientes criterios cuantitativos en cada UR:

1. Por lo menos dos metapoblaciones en drenajes diferentes (definidos aquí como Unidades Hidrológicas del USGS de 10 dígitos), y por lo menos una población aislada y robusta adicional en cada UR, muestran persistencia y estabilidad a largo plazo (aunque las poblaciones locales pueden llegar a extinguirse en las metapoblaciones) a base de un programa científico de monitoreo (vease el Apéndice K para definiciones de metapoblación, población robusta, persistencia a largo plazo, y estabilidad). La interpretación de los resultados del programa de monitoreo tomará en cuenta los ciclos de la precipitación, los períodos de sequía o períodos lluviosos, y los efectos de tales ciclos en la persistencia de la población.
2. Hábitats acuáticos de reproducción, incluyendo hábitats adecuados, restaurados, y creados que son necesarios para la persistencia de las metapoblaciones y de las poblaciones aisladas identificadas en el criterio 1, son protegidos y manejados de acuerdo con las recomendaciones en este plan.

3. El hábitat adicional necesario para la conectividad de poblaciones, la recolonización, y la dispersión es protegido y manejado para las ranas de Chiricahua, de acuerdo con las recomendaciones en este plan.
4. Las amenazas y las causas del declive han sido reducidas o eliminadas, y los compromisos del manejo a largo plazo se han establecido en cada UR tal que es poco probable que la rana de Chiricahua necesite la protección de la Ley de Especies en Peligro de Extinción en el futuro previsto.

La eliminación de la rana de la lista de especies en peligro de extinción, por UR o por otro subconjunto de la especie, no ocurrirá al menos que segmentos distintos de población sean indicados posteriormente por un proceso reglamentador. El progreso hacia la realización de los criterios de la recuperación será medido por medio de la investigación, el monitoreo continuo, y el análisis de la viabilidad de la población y el hábitat. Además, los mecanismos reguladores y los compromisos para administrar el uso de la tierra, que proporcionan la protección adecuada a largo plazo a la rana de Chiricahua y a su hábitat, deben ser puestos en acción. Estos mecanismos y compromisos deben tomar en cuenta el mantenimiento y la protección del hábitat, el manejo de las especies alóctonas, la transmisión de la enfermedad, el mantenimiento de la dinámica de metapoblaciones, y la educación pública.

Acciones Necesarias:

1. Proteger a las poblaciones de la rana de Chiricahua que todavía existen.
2. Identificar, restaurar o crear, según sea necesario, y proteger los sitios de recuperación en cada UR necesarios para sostener poblaciones y metapoblaciones viables de la rana de Chiricahua.
3. Establecer nuevas o re-establecer poblaciones anteriores en sitios seleccionados para la recuperación.
4. Añadir a las poblaciones en AMs según sea necesario para aumentar la persistencia
5. Monitorear a las poblaciones de la rana de Chiricahua y sus hábitats; monitorear la puesta en práctica del plan de recuperación.
6. Poner en práctica la investigación necesaria para apoyar las acciones de la recuperación y el manejo adaptativo.
7. Desarrollar y poner en práctica la comunicación con el público y el planeamiento de base amplia con la comunidad para fomentar el apoyo y la comprensión pública de las acciones de la recuperación.
8. Desarrollar proyectos cooperativos de conservación, tal como acuerdos de puerto de seguridad (“Safe Harbor Agreement”) y planes para la conservación del hábitat (“Habitat Conservation Plans”), con propietarios dispuestos para poner en práctica la recuperación en tierras no-federales.
9. Enmendar los planes del uso de la tierra, planes para el manejo del hábitat, y otros planes como sea necesario para ejecutar las acciones de la recuperación.
10. Trabajar con los socios tribales para fomentar la recuperación en tierras tribales.
11. Trabajar con los socios mexicanos para fomentar la recuperación en México.
12. Practicar el manejo adaptativo de tal manera que las tareas de la recuperación son revisadas por el Servicio de Pesca y Vida Silvestre (“Fish and Wildlife Service”) de los Estados Unidos, en coordinación con los subgrupos del equipo de la recuperación, al tener disponible información nueva y pertinente.

Costo total de la recuperación (mínimo): $3,413,000

Costos, en miles de dólares:

Año	Costos Mínimos: ($000's)
2005	710
2006	739
2007	763
2008	637
2009	564
2010+	Aún no determinado

Fecha de la recuperación: Si las acciones de la recuperación se ejecutan puntualmente y con éxito, y se cumplen los criterios de la recuperación, nosotros estimamos que la rana podría ser excluida de la lista de especies en peligro de extinción tan luego como el 2035.

RECOVERY PLAN USER'S GUIDE

This recovery plan has four sections: Part I contains biological information that serves as a framework to support the recovery strategy and actions, including status of the species, biology and ecology, threats, and current management; Part II outlines the recovery goal, strategy, criteria, and actions, followed by a list of recovery team members; Part III contains an implementation schedule that lists recovery actions with associated schedules, parties responsible for implementation, and estimated costs; and, Part IV contains appendices to the plan that provide guidance for implementation of recovery actions. Appendix A - the Participation Plan - contains information pertinent to creating and managing stock tanks and other populations of Chiricahua leopard frogs. Appendix A also includes a guide to sources of funding for recovery implementation. Appendix B provides information on each recovery unit as a baseline for local or regional working groups implementing recovery. Detailed recommendations for building broad-based support for recovery through outreach and education, as well as analysis of factors affecting population viability, are presented in Appendix C. Appendix D provides guidance on selecting sites for population establishment, administrative steps needed to establish populations, as well as guidance on population augmentation and establishment of refugia and holding facilities. Appendix E presents survey and preliminary monitoring protocols, and Appendices F and G provide protocols outlining the mechanics of frog captive care, transportation, release, and disease prevention. Appendices H and I provide recommendations for watershed use and maintenance, and conservation protocols for projects that may affect frogs, respectively. Those interested in establishing backyard frog refugia will find the information in Appendix J invaluable. A glossary and list of acronyms used in this document are found in Appendices K and L. Appendix M provides responses to public and peer review comments received on the draft recovery plan.

The recovery program will need the help of landowners, land managers, ranchers, volunteers, and others with an interest in conservation. If you would like to help, we suggest you contact your local or state office of the U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, or Arizona Game and Fish Department. Contacts in these agencies can be found in the recovery plan "List of Contacts". On the White Mountain Apache Reservation, contact the Wildlife and Outdoor Recreation Division (928/338-4385). On the San Carlos Apache Reservation, contact the Recreation and Wildlife Department (928-475-4758). In addition, if you cannot find answers to your specific questions in this recovery plan, we direct you to the following contacts regarding specific topics:

Funding for Recovery Projects: Partners for Fish and Wildlife Program Coordinator, U.S. Fish and Wildlife Service, Tucson, AZ (520/670-6150) and U.S. Fish and Wildlife Service, Albuquerque, NM (505/346-2525); Conservation Grants Coordinator, Natural Resource Conservation Service, Tucson, AZ (520/670-6602) and Albuquerque, NM (505/761-4425); and, Habitat Programs with the Arizona Game and Fish Department (Flagstaff – 928/774-5045; Mesa – 480/981-9400; Pinetop – 928/367-4281; Tucson – 520/628-5376). Additional contacts and resources are provided in "State and Federal Programs to Assist Landowners and Managers in Recovery Plan Implementation" in Appendix A.

Questions about the Biology, Distribution, and Legal Status of the Chiricahua Leopard Frog: Recovery Team Technical Subgroup members can help you with these questions (see "List of Contacts") or refer to Part I of the recovery plan.

- **How Would Frogs on or Near My Property Affect My Property Rights or Grazing Allotment?** For the legal implications of having a listed frog on or near your property, we suggest you contact the U.S. Fish and Wildlife Service in New Mexico (505/346-2525) or Arizona (602/242-0210). Programs such as Safe Harbor Agreements on non-Federal lands can be developed to protect landowners from liabilities associated with having a listed species on your property, while still providing conservation benefit to the frog. U.S. Fish and Wildlife Service or State Game and Fish contacts can help you with these programs. For questions concerning effects on State or Federal grazing allotments, we recommend you contact the Range Conservation Specialist with your local State (e.g. Arizona State Land Department) or Federal (Forest Service or Bureau of Land Management (BLM)) land manager for the grazing allotment in question. Some of the Stakeholders on the recovery team (see "List of Contacts") are dealing with this situation and can provide first-hand knowledge and advice.

- **What Do I Do if I Find Frogs on My Property?** Chiricahua leopard frogs are similar to several other leopard frog species. To determine if you have Chiricahua leopard frogs, contact one of the Technical Subgroup members of the Recovery Team, the U.S. Fish and Wildlife Service contacts in the above paragraph, your local State Game and Fish Office, or a qualified biologist who is permitted by the State and U.S. Fish and Wildlife Service to survey for Chiricahua leopard frogs. If the frogs are identified as Chiricahua leopard frogs, we suggest you contact a Recovery Team member, who will be able to answer your questions (see "List of Contacts").

- **What Do I Do if I Find a Frog Population in a Pond That is Drying Up?** Many frog populations, particularly during drought, are eliminated when stock ponds or other small aquatic habitats dry up. Small populations can also be eliminated due to ash or sediment flow after a fire, flooding, or other events. This recovery plan recommends salvage and temporary holding of frogs in such circumstances. The frogs can then be repatriated after the pond refills (see recovery action 1.2.13 and Appendices C, E, and I for further guidance). If you encounter a Chiricahua leopard frog population in danger of being eliminated by drought or some other natural disaster, please contact the land manager (e.g. Forest Service or BLM) or the landowner, a State Game and Fish or U.S. Fish and Wildlife Service representative, or a member of the Recovery Team (see "List of Contacts").

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PART I. BACKGROUND

The Endangered Species Act of 1973, as amended (ESA), requires preparation of recovery plans for listed species likely to benefit from the effort. This recovery plan for the Chiricahua leopard frog (*Rana chiricahuensis*) establishes a recovery goal and objectives, describes site-specific recovery actions recommended to achieve those goals and objectives, estimates the time and cost required for recovery, and identifies partners and parties responsible for implementation of recovery actions. A recovery plan presents a set of recommendations endorsed by the U.S. Fish and Wildlife Service (USFWS). This plan was developed by the Chiricahua Leopard Frog Recovery Team (Recovery Team) and the USFWS. The Recovery Team consists of a Technical Subgroup of experts on the frog and its habitats, and three Stakeholders Subgroups consisting of land owners, ranchers, mining companies, recreationists, representatives of State and Federal agencies, and other concerned citizens that were appointed by the USFWS (see "List of Contacts" for membership of each subgroup). Stakeholders prepared a report (Appendix A) to clarify methods for on-the-ground implementation of recovery actions, identify resources for funding recovery actions, and provide additional contacts to facilitate recovery plan implementation.

Status of the Species

The Chiricahua leopard frog was listed as threatened without critical habitat on June 13, 2002 (67 FR 40790). A special rule to exempt operation and maintenance of livestock tanks on non-Federal lands from the Section 9 take prohibitions was included in the listing. The species has a recovery priority number of 2C. This ranking, determined in accordance with the Recovery Priority Criteria at 48 FR 51985, is based on a high degree of threat, a high potential for recovery, and a taxonomic classification as a species. The Chiricahua leopard frog is included on the Arizona Game and Fish Department (AGFD) draft species of concern (Arizona Game and Fish Department 1996), and collection of Chiricahua leopard frogs in Arizona is prohibited by Arizona Game and Fish Commission Order 41, except where such collection is authorized by special permit. The species is not protected by state law in New Mexico, although it is designated a sensitive species by the New Mexico Department of Game and Fish (NMDGF). In Mexico, the species is considered a threatened species. Collection of threatened species is prohibited; and although Chiricahua leopard frogs have been reported in the Mexican pet trade (Diaz and Diaz 1997), the identity of these frogs is questionable. The habitat of the Chiricahua leopard frog is protected from some activities in Mexico. The species is not protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which regulates international trade.

Species Description and Taxonomy

Leopard frogs (*Rana pipiens* complex), long considered to consist of a few highly variable taxa, are now recognized as a diverse assemblage of about 29 species (Hillis *et al.* 1983, Frost 2004, Hillis and Wilcox 2005), many of which have been described in the last 30 years, and several more await description. Mecham (1968) recognized two distinct variations of "*Rana pipiens*", or the northern leopard frog, in the White Mountains of Arizona. One of these was referred to as the "southern form". The other form matched previous descriptions of *Rana pipiens*. Based on

morphology, mating calls, and genetic analyses (electrophoretic comparisons of blood proteins), Platz and Platz (1973) demonstrated that at least three distinct forms of leopard frogs occurred in Arizona, including the southern form. This southern form was subsequently described as the Chiricahua leopard frog (Platz and Mecham 1979).

Leopard frog species can be difficult to identify, but all are frogs of moderate size with dorsolateral folds and typically dark dorsal spots. The Chiricahua leopard frog is a large (up to 4.3 inches snout-urostyle length [SUL]), often green frog that is distinguished from other members of the *Rana pipiens* complex by a combination of characters, including a distinctive pattern on the rear of the thighs consisting of small, raised, cream-colored spots or tubercles on a dark background; dorsolateral folds that are interrupted and deflected medially; stocky body proportions; and relatively rough skin on the back and sides. The species also has a distinctive call consisting of a relatively long snore of one to two seconds in duration.

The range of the Chiricahua leopard frog is divided into two parts, including--1) a southern group of populations (the majority of the species' range) located in mountains and valleys south of the Gila River in southeastern Arizona, extreme southwestern New Mexico, and Mexico; and 2) northern montane populations in west-central New Mexico and along the Mogollon Rim in central and eastern Arizona (Platz and Mecham 1979). Recent genetic analyses, including a 50-loci starch gel survey, morphometrics, and analyses of nuclear DNA, support describing the northern populations of Chiricahua leopard frog as a distinct species (Platz and Grudzien 1999). In another study, frogs from these two regions showed a 2.4 percent average divergence in mitochondrial DNA sequences (Goldberg *et al.* 2004). Multiple haplotypes within *chiricahuensis* were also identified using mitochondrial DNA analysis (Benedict and Quinn 1999), providing further evidence of genetically distinct demes or groups of related populations. Based on morphological similarities, Hillis and Wilcox (2005) suggest the northern populations may be *Rana fisheri* (Vegas Valley leopard frog), a taxon from Las Vegas Valley, Nevada, considered by most to be extinct (Bradford *et al.* 2005). However, *R. fisheri* in the Vegas Valley was disjunct from Mogollon Rim *chiricahuensis* populations by about 230 miles; thus if the two are closely-related or conspecific, it presents some interesting biogeographical questions. The Ramsey Canyon leopard frog (*Rana subaquavocali*s, Platz 1993) from the Huachuca Mountains in southeastern Arizona is similar in appearance to the Chiricahua leopard frog, and genetic work supports subsuming *R. subaquavocalis* into *chiricahuensis* (Goldberg *et al.* 2004, Hillis and Wilcox 2005). Herein, we treat the Ramsey Canyon leopard frog as *R. chiricahuensis* because it is likely to be recognized as such in the near future. However, the Ramsey Canyon leopard frog is not considered a listed entity. It will remain unlisted unless and until it is subsumed into *R. chiricahuensis* in a peer-reviewed scientific publication and USFWS revises the listing of the Chiricahua leopard frog to include populations now recognized as *R. subaquavocalis*. If the northern populations of the Chiricahua leopard frog are described as a distinct species, we would also revise the Chiricauhua leopard frog listing by publishing a correction notice indicating both species are listed and distinct. In that case, we would most likely revise this plan to be a multi-species plan with appropriate recovery criteria, strategies, and actions for both species.

Population Trends and Distribution

The Chiricahua leopard frog is known currently and/or historically from cienegas (mid-elevation wetland communities often surrounded by arid environments), pools, livestock tanks, lakes, reservoirs, streams, and rivers at elevations of 3,281 to 8,890 feet in central and southeastern Arizona; west-central and southwestern New Mexico; and in Mexico, northern Sonora and the Sierra Madre Occidental of western Chihuahua and perhaps south to Durango (Platz and Mecham 1984, 1979; McCranie and Wilson 1987; Degenhardt *et al.* 1996; Sredl *et al.* 1997; Smith and Chiszar 2003; Sredl and Jennings 2005). Historical records exist for Pima, Santa Cruz, Cochise, Graham, Apache, Greenlee, Gila, Coconino, Navajo, and Yavapai counties, Arizona; and Catron, Grant, Hidalgo, Luna, Soccoro, and Sierra counties, New Mexico (Degenhardt *et al.* 1996, Sredl *et al.* 1997).

Chiricahua leopard frogs have been collected or observed at 272 localities in Arizona (Clarkson and Rorabaugh 1989; Hale 1992; R. Zweifel, Portal, Arizona, telephone conversation with Jim Rorabaugh, 1995; Rosen *et al.* 1996a and b; Snyder *et al.* 1996; Sredl *et al.* 1997; Rosen *et al.* 2002; Jones and Sredl 2004; Suhre *et al.* 2004; USFWS files). In New Mexico, the species has been collected or observed at 182 localities (Platz and Mecham 1979, Scott 1992, Jennings 1995, Jennings and Scott 1991, Painter 2000, Christman *et al.* 2003, USFWS files). We are aware of 34 localities in Mexico, including sites in northeastern Sonora, from the eastern base and foothills of the Sierra Madre Occidental in Chihuahua, and two sites in Durango (Platz and Mecham 1979, Hillis *et al.* 1983, Holycross 1998, and collection data for specimens in 16 museums). The presence of Chiricahua leopard frogs in the Sierra Madre Occidental of southern Chihuahua and Durango is unclear due to presence of similar frogs, including *Rana lemosespinali* (Webb and Baker 1984, Smith and Chiszar 2003).

Many collections of Chiricahua leopard frogs were made before 1980 (Mecham 1968, Frost and Bagnara 1977, Platz and Mecham 1979, Jennings 1995, Painter 2000). Recent surveys to document the status and distribution of the species were conducted primarily from the mid-1980s to the present (Clarkson *et al.* 1986, Rosen and Schwalbe 1988; Clarkson and Rorabaugh 1989, 1991; Wood 1991; Hale 1992; Scott 1992; Sredl and Howland 1994, 1992; Sredl *et al.* 1997, 1995, 1994, 1993; Fernandez and Bagnara 1995; Jennings 1995; Rorabaugh *et al.* 1995; Rosen 1995; Zweifel 1995; Rosen *et al.* 1996a and b; Painter 2000; Jones and Sredl 2004; Suhre *et al.* 2004). These surveys were summarized first by Jennings (1995) and then Painter (2000) for New Mexico and by Sredl *et al.* (1997) for Arizona.

In 1995, Jennings reported Chiricahua leopard frogs still occurred at 11 sites in New Mexico. Based on additional work, Painter (2000) listed 41 localities at which Chiricahua leopard frogs were found from 1994-1999. Thirty-three of these are north of Interstate 10 (northern populations) and eight are in the southwestern corner of the state (southern populations). Thirty-one of the 41 populations were verified extant (currently existing) during 1998-1999 (Painter 2000). However, during May-August 2000, the Chiricahua leopard frog was found extant at only eight of 34 of the sites (personal obervations of C. Painter, Technical Subgroup, 2000). Three populations east of Hurley in Grant County declined or went extinct during 1999-2000 (personal observations of R. Jennings, Technical Subgroup, 2000), and preliminary data indicate

populations on the Mimbres River, also in Grant County, and at Deep Creek Divide have experienced significant die-offs (personal observations of C. Painter and R. Jennings, 2004).

Sredl *et al.* (1997) reported that Chiricahua leopard frogs were found at 61 sites in southeastern Arizona (southern populations) and 15 sites in central and east-central Arizona (northern populations) from 1990-1997. To enable comparison of the Arizona and New Mexico status information, the number of sites at which Chiricahua leopard frogs were observed from 1994-2001 in Arizona was tallied. Based on available data, particularly Sredl *et al.* (1997), Rosen *et al.* (1996b), and USFWS files, Chiricahua leopard frogs were observed at 87 sites in Arizona from 1994 to 2001, including 21 northern localities and 66 southern localities. Many of these sites have not been revisited in recent years; however, most populations are now extirpated from the Galiuro Mountains (Jones and Sredl 2004), frogs have not been seen for several years in the Chiricahua mountains, while others, such as in the Buckskin Hills area of the Coconino National Forest, were recently (2000-2001) discovered. In 2000, the species was also documented for the first time in the Baboquivari Mountains, Pima County, Arizona (USFWS files, Phoenix, AZ), extending the range of the species approximately 12 miles to the west. However, during a drought in 2002, populations in the Baboquivari Mountains and most populations in the Buckskin Hills were extirpated due to drying of stock tanks inhabited by the frogs.

Intensive and extensive surveys were conducted by AGFD in Arizona from 1990-1997 (Sredl *et al.* 1997). Six-hundred and fifty-six surveys were conducted for ranid frogs (frogs in the family Ranidae) within the range of the Chiricahua leopard frog in southeastern Arizona. Clarkson and Rorabaugh (1989), Wood (1991), Hale (1992), Rosen *et al.* (2002, 1996a and b, 1994), Jones and Sredl (2004), Suhre *et al.* (2004) and others have also extensively surveyed wetlands in southeastern Arizona. It is unlikely that many additional new populations will be found there. A greater potential exists for locating frogs at additional localities in Arizona's northern region, as demonstrated by several new populations discovered in the Buckskin Hills during 2000-2001. Sredl *et al.* (1997) conducted 871 surveys for ranid frogs in the range of the northern localities, but report that only 25 of 46 historical Chiricahua leopard frog localities were surveyed during 1990-1997. The majority of these unsurveyed historical localities are in the mountains north of the Gila River in east-central Arizona. Additional extant populations of Chiricahua leopard frogs may occur in this area. Based on the most recent surveys, as of this writing, Chiricahua leopard frogs are likely extant at about 38 sites in Arizona.

Of the historical localities in New Mexico, 24 have imprecise locality information that precludes locating or revisiting them. Many others are on private lands to which the owners have denied access to biologists (the privately-owned Gray and Ladder ranches are notable exceptions). As in Arizona, potential habitat within the range of the southern populations has been surveyed more extensively than that of the northern populations. From 1990-1991, Scott (1992) conducted extensive surveys of the Gray Ranch, which contains much of the Chiricahua leopard frog habitat in southwestern New Mexico. Observations from numerous other herpetologists were included within his reports, and ranch owners and workers were interviewed to locate potential habitats. Jennings (1995) surveyed other potential habitats in southwestern New Mexico outside of the Gray Ranch in the Peloncillo Mountains. Other herpetologists working in that area, including Charles Painter (Technical Subgroup) and Andy Holycross (Arizona State

University), also worked extensively in this area. Probably few if any unknown populations of Chiricahua leopard frogs occur in southwestern New Mexico.

Surveys in the northern portion of the species' range in New Mexico are less complete. Jennings (1995) believed that the wilderness areas of the Gila National Forest have the greatest potential for supporting additional extant populations and for securing an intact metapopulation (a set of local populations that interact via individuals moving among local populations) that would have a good chance of long-term persistence. Recent surveys (1995-1999) have discovered four extant populations in the Gila Wilderness (Painter 2000).

Currently in New Mexico, 30-35 populations of Chiricahua leopard frogs are likely extant, including at least one population in each of the major drainages within its range. Within the San Francisco drainage, populations persist in the Upper Tularosa River near its spring source and downstream to its confluence with Apache Creek. Private lands along Apache Creek preclude efforts to determine whether populations persist there. Small populations in the upper San Francisco River near the Box and in Cave Creek (NW of Reserve) may have gone extinct since their presence was documented in 2001 and 2002. Populations along Negrito Creek, which were once common, have only been represented by a single individual observed during surveys in 2002. A presumed metapopulation in the Deep Creek Divide area that was represented by nine local populations inhabiting earthen stock tanks as recently as the summer of 2002 has been reduced to four populations. Four of the largest local populations (potential source populations, all >500 individuals) began experiencing severe die-offs in September 2002 and have been reduced to populations of a few tadpoles and post-metamorphic individuals. Chytridiomycosis has been documented in the Deep Creek Divide area and appears responsible for the die-offs. Small populations likely persist in Deep Creek and Devil's Creek. Populations in Pueblo Creek and its tributary Chimney Rock Canyon have not been observed since the early 1990s. The status of small populations along Blue Creek and its tributaries in New Mexico, documented in the late 1990s and early 2000s, have not been recently assessed. Moderate numbers of frogs can be found near Beaver Spring along the main stem of the San Francisco River, but these areas are also inhabited by American bullfrogs.

Chiricahua leopard frogs may persist in each of the forks of the upper Gila River. Along the West Fork of the Gila River, small populations have been documented near the mouth of Turkeyfeather Canyon and upstream from the mouth of White Creek, but their status has not been evaluated since 2001. Egg masses and calls were detected in the Meadows along the Middle Fork of the Gila River. These observations need corroboration. No frogs are currently known from the East fork of the Gila River, but populations persist along Main Diamond Creek, Black Canyon near its confluence with the East fork, and in Black Canyon near the confluence with Aspen Creek. Along the lower mainstem of the Gila River in New Mexico, frogs are known only from the upper reaches of one tributary, Blue Creek.

Within the Mimbres Drainage, populations of frogs occur at Moreno Spring (private property) and adjacent stretches of the Mimbres River (some Nature Conservancy property) near the pueblo of Mimbres, near the NM 152 bridge, and near San Juan (also Nature Conservancy property). Small populations persisted in 2002 on Chino Mine Company property east of Hurley at Brown Spring, in Bolton Canyon, Ash Spring, Apache Tank, and perhaps in Lucky Bill

Canyon. Other populations in West Lampbright, Main Rustler, West Rustler, and Martin canyons are likely extinct due to chytridiomycosis.

The distribution of the Chiricahua leopard frog in Mexico is unclear, as systematic or intensive surveys for Chiricahua leopard frogs have not been conducted. Platz and Mecham (1979) list 10 localities for Chiricahua leopard frogs in the Sierra Madre Occidental, including nine from Chihuahua and one at El Salto, Durango. They also note a specimen from the Santa Cruz River near the U.S. border in Sonora. Hillis *et al.* (1983) note an additional specimen for Durango at Rio Chico. Smith and Chiszar (2003) list an additional four localities from southwestern Chihuahua and note that the species occurs east of the continental divide in Chihuahua. Holycross (1998) observed frogs he believed were Chiricahua leopard frogs at Rancho El Pinito in the Sierra San Luis, Sonora. As well, they were reported from the Ajos-Bavispe area by The Nature Conservancy (undated) and in the upper San Pedro River drainage in the southern end of the San Rafael Valley and near Cananea (IMADES 2003). Based on a search of specimens in 16 museums, Chiricahua leopard frogs have been collected in Sonora from near the Santa Cruz River, Cananea, Sierra los Ajos, Agua Prieta, and Cajon Bonito south to the vicinity of Yecora.

It is expected that the species almost certainly occurs or occurred at numerous localities other than those reported here. The identity of leopard frogs in southern Chihuahua (and perhaps Durango) is in some question. Webb and Baker (1984) concluded that frogs from southern Chihuahua were not Chiricahua leopard frogs, as expected (but see Platz and Mecham 1979, Hillis *et al.* 1983, and Smith and Chiszar 2003). Reports of the species from Aguascalientes (Diaz and Diaz 1997) are similarly questionable and should be confirmed by genetic analysis. The taxonomic status of *chiricahuensis*-like frogs in Mexico from southern Chihuahua to the state of Aguascalientes is unclear, and in this region other leopard frogs, including *Rana montezumae* and *R. lemosespinali*, may be mistaken for the Chiricahua leopard frog. Due to these uncertainties, for the purposes of this recovery plan we consider the range of the Chiricahua leopard frog to extend no farther south than central Chihuahua.

The Chiricahua leopard frog is reported absent from a majority of surveyed historical localities. For example, in New Mexico, Jennings (1995) found Chiricahua leopard frogs at six of 33 sites supporting the species during the previous 11 years. During 1998-1999, Chiricahua leopard frogs were found at 31 of the 41 sites where they had been documented after 1993 (Painter 2000); however, subsequent surveys in 2000 only revealed frogs at eight of 34 of these sites (USFWS files, Phoenix, AZ). In Arizona, Clarkson and Rorabaugh (1989) found the species at only two of 36 sites that supported Chiricahua leopard frogs in the 1960s and 1970s. Sredl and Howland (1994) reported finding Chiricahua leopard frogs at only 12 of 53 Arizona historical sites. In 1994, during surveys of 175 wetland sites in southeastern Arizona, Rosen *et al.* (1994) reported the Chiricahua leopard frog was extant at 19 historical and new sites, but was not found at 32 historical localities. Throughout Arizona, Sredl *et al.* (1997) found the species present at 21 of 109 historical localities. Based on the most recent survey data, currently the Chiricahua leopard frog is likely extant at about 14 and 16-19 percent of historical localities in Arizona and New Mexico, respectively.

Determining whether a species is declining based on its presence or absence at historical sites is difficult. Where frogs are observed at a particular site they are considered extant. However, a failure to find frogs does not necessarily indicate the species is absent. Skelly *et al.* (2003) cautioned that comparing historical versus present-day presence/absence can lead to overestimates of decline and distributional change, particularly when current presence/absence is based on only one or two years of resurvey data. Corn (1994) notes that leopard frogs may be difficult to detect, museum records do not always represent breeding localities, collections have occurred from marginal habitat, and museum and literature records often represent surveys over long periods of time, which ignores natural processes of geographical extinction and recolonization (e.g. some sites are not occupied continuously). These latter natural processes may be particularly important for the Chiricahua leopard frog because its habitats are often small and very dynamic. Because the Chiricahua leopard frog and other southwestern leopard frogs exhibit a life history that predisposes them to high rates of extirpation and recolonization (Sredl and Howland 1994), absence from at least some historical sites is expected.

In relatively simple aquatic systems such as most stock tanks and stream segments, the failure of experienced observers to find frogs indicates that frogs are likely absent. Howland *et al.* (1997) evaluated visual encounter surveys at five leopard frog localities. At sites with known populations that were not dry, frogs were detected in 93 of 100 surveys conducted during the day from April through October. During a drought in 1994, Rosen *et al.* (1996a, 1994) surveyed all Chiricahua leopard frog localities known at that time in southeastern Arizona and other accessible waters, and discussed locations of waters and faunal occurrence with landowners. By focusing on aquatic sites that did not go dry, and through careful and often multiple surveys at each site, the authors were able to define distribution at a time when aquatic faunal patterns were clear. The authors believed that nearly all potential habitats were surveyed, and if frogs were present they would have been detectable at most sites.

Although recent survey data suggest that the species is absent from about 85 percent of historical sites in the U.S., we include here further analysis to investigate whether extirpations represent natural fluctuations or long-term declines caused by human impacts (Pechman *et al.* 1991, Blaustein *et al.* 1994).

Numerous studies indicate that declines and extirpations of Chiricahua leopard frogs are at least in part caused by predation and possibly competition by non-native organisms, including fishes in the family Centrarchidae (*Micropterus* spp., *Lepomis* spp.), American bullfrogs (*Rana catesbeiana*), tiger salamanders (*Ambystoma tigrinum mavortium*), crayfish (*Orconectes virilis* and possibly others), and several other species of fishes, including, in particular, catfishes (*Ictalurus* spp. and *Pylodictus oliveris*) and trout (*Salmo* spp. and *Salvelinus* spp.) (Clarkson and Rorabaugh 1989, Sredl and Howland 1994, Fernandez and Bagnara 1995, Snyder *et al.* 1996, Rosen *et al.* 1994, 1996a, Fernandez and Rosen 1998). For instance, in the Chiricahua region of southeastern Arizona, Rosen *et al.* (1996a) noted an alarming expansion of non-native predatory vertebrates and decline of Chiricahua leopard frogs over the previous two decades. Chiricahua leopard frogs were primarily limited to habitats subject to drying or near drying, such as stock tanks. These habitats are not favored by non-native predatory fishes and American bullfrogs, but because they are not stable aquatic habitats they are marginal for leopard frogs (Rosen *et al.* 1994).

Figure 1: Halfmoon Tank in the Dragoon Mountains, Coronado National Forest, Arizona during a drought. This site supported a robust population of Chiricahua leopard frogs until recently. Photo by J. Rorabaugh.

Additional evidence that the observed absence of Chiricahua leopard frogs from historical sites is not the result of a natural phenomenon emerges from analysis of regional occurrence. If the extirpation of the Chiricahua leopard frog was a natural artifact of metapopulation dynamics or other population-level processes, then an observer would not expect to find the species absent from large portions of its range. Rather, Chiricahua leopard frogs might be absent from some historical sites, but would still be found at other new or historical sites in the region. In New Mexico, extant Chiricahua leopard frog populations occur in each of the six major drainages where the species was found historically (Tularosa/San Francisco, Mimbres, Alamosa/Seco/Rio Grande, Gila, Playas, and Yaqui). However, occurrence of the frog in these drainages is characterized by few, mostly small, isolated populations. Populations in the Playas drainage are probably limited to one or two introduced populations in steep-sided livestock tanks from which frogs cannot escape.

In Arizona, the species is known to be extant in seven of eight major drainages of historical occurrence (Salt, Verde, Gila, San Pedro, Santa Cruz, Yaqui/Bavispe, and Magdalena river drainages), but may be extirpated from the Little Colorado River drainage on the northern edge of the species' range. Within the extant drainages, the species was not found recently in some major tributaries and/or from river mainstems. For instance, the species was not reported from 1995 to the present from the following drainages or river mainstems where it historically occurred: White River, West Clear Creek, Tonto Creek, East Verde River, San Carlos River,

upper San Pedro River mainstem, Santa Cruz River mainstem, Aravaipa Creek, Babocomari River mainstem, and Sonoita Creek mainstem. In southeastern Arizona, no recent records (1995 to the present) exist for the following mountain ranges or valleys: Pinaleno Mountains, Peloncillo Mountains, and Sulphur Springs Valley. Recent surveys suggest the species may be extirpated from the Chiricahua Mountains, as well. Moreover, the species is now absent from all but one of the southeastern Arizona valley bottom cienega complexes. The Chiricahua leopard frog is known or suspected to have been historically present, and at least in some cases, very abundant (Wright and Wright 1949) in each major southeastern Arizona valley bottom cienega complex. It is thought to be breeding in small numbers in the Empire Cienega, but is absent as a breeding species from all others, including Arivaca Cienega, upper Santa Cruz Valley cienegas, Babocomari Cienega, marshy bottoms of the upper San Pedro River, Whitewater Creek and Hooker Cienega in the Sulphur Springs Valley, Black Draw and associated cienegas, and San Simon Cienega. A small breeding population exists at O'Donnell Creek and cienega, but recruitment to the population appears to be limited due to predation by non-native species and long-term viability of the population may depend on immigrants (Rosen *et al.* 2002). These large, valley bottom cienega complexes may have supported the largest populations in southeastern Arizona, but are now so overrun with non-native predators that they do not presently support the Chiricahua leopard frog in viable numbers. These apparent regional extirpations provide further evidence that the species is disappearing from its range. Once extirpated from a region, natural recolonization of suitable habitats is unlikely to occur in the near future.

Where the species is still extant, sometimes several small populations are found in close proximity, suggesting metapopulations are important for preventing regional extirpation (Sredl *et al.* 1997). Disruption of metapopulation dynamics is likely an important factor in regional loss of populations (Sredl and Howland 1994, Sredl *et al.* 1997). Chiricahua leopard frog populations are often small and their habitats are dynamic, resulting in a relatively low probability of long-term population persistence. However, if populations are relatively close together and numerous, extirpated sites can be recolonized. The value of the metapopulation structure to the status of the species is tempered by disease, which is more likely to affect metapopulations than isolated populations (see discussion under Reasons for Listing/Threats - *Disruption of Metapopulation Dynamics*, below).

Life History and Population Ecology

The life history of the Chiricahua leopard frog can be characterized as a complex life cycle, consisting of eggs and larvae that are entirely aquatic and adults that are primarily aquatic. Egg masses of Chiricahua leopard frogs have been reported in all months except January, November, and December, but reports of oviposition in June are uncommon (Zweifel 1968, Frost and Bagnara 1977, Frost and Platz 1983, Scott and Jennings 1985, Sredl and Jennings 2005, Sredl, unpublished data). Zweifel (1968) noted that breeding in the early part of the year appeared to be limited to sites where the water temperatures do not get too low, such as spring-fed sites. Frogs at some of these sites may oviposit year-round (Scott and Jennings 1985). Frost and Platz

Figure 2: Chiricahua leopard frog egg mass, Apache County, Arizona. Photo by J. Rorabaugh.

(1983) studied populations of Chiricahua leopard frogs in Arizona and New Mexico, and noted egg masses in March, April, May, June, July, and August. They divided egg-laying activity into two distinct periods with respect to elevation. Populations at elevations below 5,900 feet tended to oviposit from spring through late summer, with most activity taking place before June. Populations above 5,900 feet bred in June, July, and August. Scott and Jennings (1985) found a similar seasonal pattern of reproductive activity in New Mexico (February through September) as Frost and Platz (1983), although they did not note elevational differences. Additionally, they noted reduced oviposition in May and June. In the Sulfur Springs Valley of southeastern Arizona, egg masses were found most frequently between late March and late May, although occasional egg masses were found in the summer and early fall (Frost and Bagnara 1977). Jennings (1988, 1990) studied five populations of Chiricahua leopard frogs in New Mexico from 1987 to 1989, and found annual and site-specific variation in all breeding activities. Amplexus is axillary and the male fertilizes the eggs as the female attaches a spherical mass to submerged vegetation. Numbers of eggs in a mass range from 300 to 1,485 (Jennings and Scott 1991) and apparently are correlated with female body size.

Hatching time of egg masses in the wild has not been studied in detail. Eggs of the Ramsey Canyon leopard frog hatch in approximately 14 days depending on temperature (Platz 1997), and hatching time may be as short as eight days in geothermally influenced springs (Jennings,

unpublished data). After hatching, tadpoles remain in the water, where they feed and grow. Jennings (1990) found that tadpoles in warm springs appear to grow continuously, while growth of those in cold-water sites appeared to be arrested or retarded during the winter, but tadpoles can remain active under ice in water at 41˚F (Jennings, personal observations). Tadpoles metamorphose in three to nine months (Jennings 1988, 1990), and may overwinter.

Age and size at reproductive maturity are not well known. In southeastern Arizona, juvenile frogs and late-stage tadpoles introduced to an outdoor enclosure in May and June 1994 reproduced in September 1994 (Rosen and Schwalbe 1998). The smallest males to exhibit secondary sexual characteristics from study sites in Socorro and Catron County, New Mexico were 2.10 inches and 2.21 inches SUL, respectively (Jennings, unpublished data). Size at which females reach sexual maturity is not known. Adult body sizes range up to 4.3 inches SUL (Sredl and Jennings 2005).

Proximate cues that stimulate mating have not been well studied. Using data collected from a long-term captive colony, Fernandez (1996) states that oviposition may be stimulated by rainstorms. Platz (1997), studying wild populations of the Ramsey Canyon leopard frog, noted that oviposition does not appear to be correlated with rain, but instead may be correlated with changes in water temperature. Oviposition occurred on 10 of 11 nights shortly before or slightly after a decrease in water temperature.

Breeding migrations described for some amphibians have not been noted in Chiricahua leopard frogs (Sredl and Jennings 2005). Male Chiricahua leopard frogs typically call above water, but may also advertise underwater (Degenhardt *et al.* 1996). Calling males may defend territories and have been observed to engage in fisticuffs with other presumed males. This site defense appears to be transient however. Other forms of territorial defense are not known (Jennings, unpublished data).

Although scoring of annuli (annual growth rings in bones) in Chiricahua leopard frogs is more difficult than in lowland leopard frogs (Collins *et al.* 1996), preliminary skeletochronology of Chiricahua leopard frogs indicate that they can live as long as six years (Durkin 1995). Skeletochronology of Ramsey Canyon leopard frogs indicated that 47 percent of sampled adults were age six or older. The oldest frogs were estimated at 10 years post-metamorphosis (Platz *et al.* 1997).

No comprehensive studies of the feeding behavior or diet of Chiricahua leopard frog larvae or adults have been conducted. Larval Chiricahua leopard frogs are primarily herbivorous. Available food items at one site examined within the range of this species include bacteria, diatoms, phytoplankton, filamentous green algae, water milfoil (*Myriophyllum* sp.), duckweed (*Lemna minor*), and detritus (Marti and Fisher 1998). Captive larvae ate spinach, romaine lettuce, cucumber slices, frozen trout, duckweed, spirulina type fish foods, and rabbit pellets. Captive juvenile frogs ate crickets (Demlong 1997). The diet of Chiricahua leopard frog adults likely contains a wide variety of insects and other arthropods (Degenhardt *et al.* 1996). Field *et al.* (2003) documented a hummingbird in the diet of the Ramsey Canyon leopard frog. Stomach analyses of other members of the leopard frog complex from the western United States show a wide variety of prey items including many types of aquatic and terrestrial invertebrates (e.g.,

snails, spiders, and insects) and vertebrates (e.g., fish, other anurans (frogs and toads) (including conspecifics), and small birds; Stebbins 1951).

Although post-metamorphic Chiricahua leopard frogs are generally inactive between November and February, a detailed study of wintertime activity or habitat use has not been done. Jennings (1988, 1990) studied five populations of Chiricahua leopard frogs in New Mexico from 1987-1989. Among sites, the number of frogs observed during diurnal surveys was best predicted by month of the year, diurnal air temperature, and time of day. Time of day was negatively associated with frog numbers, indicating frogs were more numerous early in the day, before temperatures elevated. Number of frogs observed during nocturnal surveys among sites was best predicted by nocturnal water temperature and amount of wind. Frogs were most abundant when water temperatures were warmer and when winds were calmer. The number of egg masses observed during diurnal surveys of all sites was best predicted by the number of frogs observed during diurnal surveys. Only diurnal water temperature provided predictive power of number of egg masses at any single site included in the study.

Detailed studies of the potential variety of Chiricahua leopard frog predators have not been conducted. However, tadpoles are likely preyed upon by aquatic insects, including belostomatids, notonectids, dytiscids, and anisopterans, and vertebrates including native and non-native fishes, garter snakes (*Thamnophis* spp.), great blue herons (*Ardea herodias*), and other birds. Predators of juvenile and adult frogs likely include native and non-native fishes, American bullfrogs, garter snakes, great blue herons, and mammals including rats, coyotes, gray foxes, raccoons, ring tail cats, coatis, black bears, badgers, skunks, bobcats, and mountain lions. Zweifel (2006) observed predation of adult and juvenile Chiricahua leopard frogs by black-necked gartersnakes.

Adult and juvenile Chiricahua leopard frogs avoid predation by hopping to water (Frost and Bagnara 1977). Among members of the *Rana pipiens* complex, Chiricahua leopard frogs possess the unusual ability to significantly darken their ventral skin under conditions of low reflectance and low temperature (Fernandez and Bagnara 1991; Fernandez and Bagnara 1993). In the clear, swiftly-moving streams they inhabit (low albedo environments) this trait is thought to aid in escape of predators by reducing the amount of attention that bright flashes of white ventral skin would induce. At low temperatures, cold-blooded animals are unable to swiftly flee. Under these conditions, blending in with surroundings may be the most effective form of predator avoidance. Other anti-predator mechanisms have not been identified, but deep water, vegetation, undercut banks, root masses, and other cover sites may provide important retreats.

Dispersal and Metapopulation Ecology

Individual frogs may shift their home ranges via dispersal for a variety of reasons, including competition, predation, or unfavorable environmental conditions (Stebbins and Cohen 1995). Where such dispersal results in movement of frogs among local populations and discrete aquatic habitats, such movement facilitates the creation of metapopulations. To define metapopulations of the Chiricahua leopard frog, some knowledge of the ability of this species to move among aquatic sites is required. Amphibians, in general, have limited dispersal and colonization

abilities due to physiological constraints, limited movements, and high site fidelity (Blaustein *et al.* 1994); however, long-distance dispersal is difficult to detect (Marsh and Trenham 2001).

Detailed studies of dispersal and metapopulation dynamics of Chiricahua leopard frogs have not been conducted. However, Jennings and Scott (1991) noted that maintenance of corridors used by dispersing juveniles and adults that connect disjunct populations may be critical to preserve populations of frogs and other aquatic organisms. As a group, leopard frogs are surprisingly good at dispersal. In Michigan, young northern leopard frogs (*Rana pipiens*) commonly move up to 0.5 mile from their place of metamorphosis, and three young males established residency up to 3.2 miles from their place of metamorphosis (Dole 1971). Both adults and juveniles wander widely during wet weather (Dole 1971). In the Cypress Hills of southern Alberta, young-of-the year northern leopard frogs successfully dispersed to downstream ponds 1.3 mile from the source pond, upstream 0.6 mile, and overland 0.25 mile. At Cypress Hills, a young-of-the-year northern leopard frog moved 5 miles in one year (Seburn *et al.* 1997). After the first rains in the Yucatan Peninsula, leopard frogs have been collected a few miles from water (Campbell 1998). In New Mexico, Jennings (1987) noted collections of Rio Grande leopard frogs from intermittent water sources and suggested these were frogs that had dispersed from permanent water during wet periods.

Dispersal of leopard frogs away from water in the arid Southwest may occur less commonly than in mesic environments in Alberta, Michigan, or the Yucatan Peninsula during the wet season. However, there is evidence of substantial movements even in arid regions of Arizona. The Rio Grande leopard frog (*Rana berlandieri*) in southwestern Arizona has been observed to disperse at least one mile from any known water source during the summer rainy season (Rorabaugh 2005). Frogs may actively traverse streamcourses or uplands, and tadpoles may be carried passively along streamcourses.

The maximum distance moved by a radio-telemetered Chiricahua leopard frog in New Mexico was 2.2 miles in one direction (preliminary findings of telemetry study by R. Jennings and C. Painter, Technical Subgroup, 2004). In 1974, Frost and Bagnara (1977) noted passive or active movement of Chiricahua and Plains (*Rana blairi*) leopard frogs for 5 miles or more along West Turkey Creek in the Chiricahua Mountains. In August 1996, Rosen and Schwalbe (1998) found up to 25 young adult and subadult Chiricahua leopard frogs at a roadside puddle in the San Bernardino Valley, Arizona. They believed that the only possible origin of these frogs was a stock tank located 3.4 miles away. Rosen *et al.* (1996a) found small numbers of Chiricahua leopard frogs at two locations in Arizona that supported large populations of non-native predators. The authors suggested these frogs could not have originated at these locations because successful reproduction would have been precluded by predation. They found that the likely source of these animals was populations 1.2-4.3 miles distant. In the Dragoon Mountains, Arizona, Chiricahua leopard frogs bred at Halfmoon Tank, but frogs would occasionally turn up at Cochise Spring (0.8 mile down canyon in an ephemeral drainage from Halfmoon Tank) and in Stronghold Canyon (1.1 mile down canyon from Halfmoon Tank). There is no breeding habitat for Chiricahua leopard frogs at Cochise Spring or Stronghold Canyon, thus it appears observations of frogs at these sites represent immigrants from Halfmoon Tank. In the Chiricahua Mountains, a population of Chiricahua leopard frogs disappeared from Silver Creek stock tank after the tank dried up; but frogs then began to appear in Cave Creek, about 0.6 mile away, again

suggesting immigration. Movements by leopard frogs away from water do not appear to be random. Streams are important dispersal corridors for young northern leopard frogs (Seburn *et al.* 1997). Displaced northern leopard frogs will home, and apparently use olfactory and auditory cues, and possibly celestial orientation, as guides (Dole 1968, 1972). Rainfall or humidity may be an important factor in dispersal because odors carry well in moist air, making it easier for frogs to find other wetland sites (Sinsch 1991).

Where several populations of Chiricahua leopard frog occur within close proximity (separated by five miles or less), functional metapopulations may exist. Two areas of the Galiuro Mountains of Arizona have supported a total of 12 extant localities since 1994, including four localities in the northern end of the range and eight in the southern end. A similar cluster of seven localities occurred in the Dragoon Mountains, Arizona. In the Buckskin Hills of the Coconino National Forest, Arizona, 10 stock tank populations occurred close enough together to consider them a metapopulation. Unfortunately, these areas now support only one or two known populations each (personal observations of S. Hedwall and S. MacVean, Mogollon Rim Stakeholders, 2006; and A. King and L. Jones, Southeastern Arizona Stakeholders, 2006). Such metapopulations may exist or have recently existed elsewhere, for instance, in the Sycamore Canyon area west of Nogales, the southwestern quarter of the San Rafael Valley, and the Crouch Creek area of Arizona; and in New Mexico, east and northeast of Hurley, the Deep Creek Divide, and in the Frieborn Canyon-Dry Blue Creek area. Metapopulations, particularly the larger examples, are critical to long-term survival of the species. Also critical are large populations, such as on the Tularosa River, New Mexico, and Sycamore Canyon, Arizona, which are expected to experience relatively low extinction rates and may serve as source populations for colonization of nearby suitable habitats. Unfortunately, these large populations and metapopulations are the most likely to contract infectious disease because they are not isolated. This increases the concern about disease and underscores the importance of minimizing the likelihood of human-caused disease transmission. Population declines or extirpation associated with chytridiomycosis have recently occurred near Hurley and in the Deep Creek Divide area.

Population and Habitat Viability Analysis

A Population and Habitat Viability Analysis was conducted for this species during recovery plan preparation (see Appendix C). An analysis of this type, particularly when combined with public involvement in the interpretation of PHVA results and their use in the construction of integrated and achievable species and habitat management alternatives, can be an extremely useful tool for investigating current and future risk of wildlife population decline or extinction. The population viability model, Vortex, was used to model the viability of populations under varying future scenarios. The Vortex package is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. Because our knowledge of the life history and population dynamics of the Chiricahua leopard frog is incomplete, data inputs to the model are often based on expert opinion or surrogate species; thus although the results must be considered tentative and should be used cautiously, they are the best information available regarding factors that affect population viability.

Habitat Characteristics/Ecosystems

Habitat types

The Chiricahua leopard frog is currently a habitat specialist in the sense that its breeding habitat now falls within a narrow portion of the continuum from small, shallow, ephemeral, and unpredictable waters to large, deep, predictable, and perennial waters. It is excluded from ephemeral habitats by its requirements for surface moisture for adult survival and a relatively long larval period (minimum of 3 months). They are often excluded from perennial habitats by the presence of non-native predatory and competing species of fishes, frogs, and crayfish. Prior to the arrival of the American bullfrog, the Chiricahua leopard frog was the most aquatic of frogs in the Southwest, with the exception of the Tarahumara frog (*Rana tarahumarae*). Thus, they are pinched between these two opposing sets of processes. In the Southwest, leopard frogs are currently so strongly impacted by harmful non-native species, which are most prevalent in perennial waters, that their occupied niche is increasingly restricted to environments that tend to be ephemeral and unpredictable. This increasingly narrow realized niche is a primary reason for the threatened status of the Chiricahua leopard frog.

Despite this current specialization, which is usual for most members of the leopard frog radiation but is accentuated in the Southwest, leopard frogs are capable of occupying a broad range of environmental types in the absence of aquatic predatory species, particularly non-native ones. Chiricahua leopard frogs were historically habitat generalists and have been found in a variety of natural and man-made aquatic systems (Mecham 1968, Zweifel 1968, Frost and Bagnara 1977, Scott and Jennings 1985, Sredl and Saylor 1998). Natural systems include rivers, permanent streams, permanent pools in intermittent streams, beaver ponds, cienegas (i.e., wetlands), and springs. Artificial systems in which they have been recorded include earthen cattle tanks, livestock drinkers, irrigation sloughs or acequias, wells, abandoned swimming pools, ornamental back yard ponds, and mine adits at elevations of 3,281 to 8,890 feet. Even though Chiricahua leopard frogs are found in intermittent bodies of water, mechanisms by which they survive the loss of surface water are unknown. However, Southwestern leopard frogs, including the Chiricahua leopard frog, have been observed to survive drought by burrowing into muddy cracks and holes around drying water sources (Howland *et al.* 1997, personal observations of J. Rorabaugh, 2002). Some habitat types may be particularly important. Year-round flow and constant water temperature that permit year-round adult activity and winter breeding, and the depauperate fish communities of thermal springs, make these sites particularly important breeding sites for Chiricahua leopard frogs in New Mexico (Scott and Jennings 1985).

Principle historical habitats included montane streams and springs, and valley bottom cienegas and streams or rivers. Based on published literature, field notes, and museum records, Chiricahua leopard frogs in southeastern Arizona were most abundant under natural conditions in lowland cienegas and marshy streams, which are more productive and had a greater aerial extent than suitable montane aquatic systems. This suggests that an understanding of leopard frog use of cienegas, and restoration of cienega populations, may be essential to recovery of the frog in southeastern Arizona and potentially elsewhere. Historically a metapopulation relationship between montane and valley floor populations may have existed, with the intervening bajadas

being only sparsely or temporarily occupied. The consequences of this for population genetics and leopard frog recovery have not been explored.

In natural cienega settings, water levels would have fluctuated over long periods and on a seasonal basis, creating significant areas in which leopard frog tadpoles would have thrived in the presence of little competition or predation from fishes. Current situations in cienegas retain little of this possibility; most cienegas have been reduced, dammed, or otherwise simplified, and fish, even native fish, tend to have been spread throughout the waters of cienegas. The consequences of this for Chiricahua leopard frog populations have not been evaluated but are likely to be significant.

Another component of habitat suitability is survival of the emerging fungal disease chytridiomycosis. Evidence has accumulated that Southwestern leopard frogs often survive best, and maintain highest abundances, at sites where chytridiomycosis has not arrived, or, most notably, at warm sites where the frogs may be able to survive with the disease or clear it from their systems. This indicates that warmer, southern exposures, lower elevations, and especially warm springs, may be critical for the persistence of native leopard frogs in the Southwest as the effects of this disease continue to emerge**.**

In New Mexico, 67 percent of sites occupied by Chiricahua leopard frogs from 1994-1999 were creeks or rivers, 17 percent were springs or spring runs, and 12 percent were stock tanks (Painter 2000). In Arizona, slightly more than half of all known historical localities are natural lotic systems, a little less than half are stock tanks, and the remainder lakes and reservoirs (Sredl *et al.* 1997). Sixty-three percent of populations extant in Arizona from 1993-1996 were found in stock tanks (Sredl and Saylor 1998). Blomquist (2003a) suggests that some aquatic sites are "activity centers" at which breeding, foraging, and overwintering occur. Upland and other aquatic sites serve as dispersal and possibly foraging and temporary breeding habitat, while disturbed or developed sites may act as habitat barriers that decrease the likelihood of successful dispersal or act as population sinks.

<u>Habitat characteristics/use</u>

No formal studies of habitat use by Chiricahua leopard frogs have been completed. However, important general characteristics include permanent or nearly permanent water that is free of or contains low densities of non-native predators. The role of habitat heterogeneity within the aquatic and terrestrial environment is unknown, but is likely to be important: shallow water with emergent and perimeter vegetation provide egg deposition, tadpole and adult thermoregulation or basking sites, and foraging sites, while deeper water, root masses, and undercut banks provide refuge from predators and potential hibernacula (personal observations of M. Sredl, Technical Subgroup). Aquatic sites should have substrate (some mud and not just bare rock as in some tinaja pools) that will allow for the growth of algae and diatoms to serve as food for developing tadpoles and to allow for overwintering hibernation sites. Most perennial waters supporting Chiricahua leopard frogs possess fractured rock substrata, emergent or submergent vegetation, deep water, root masses, undercut banks, or some combination of these features that frogs may use as refugia from predators and extreme climatic conditions (Jennings, unpublished data). Chiricahua leopard frogs likely overwinter at or near breeding sites, although microsites for these

"hibernacula" have not been studied. Other leopard frogs typically overwinter at the bottom of well-oxygenated ponds or lakes, and may bury themselves in the mud (Harding 1997, Nussbaum *et al.* 1983, Cunjak 1986). Northern leopard frogs have also been found during the winter in caves (Rand 1950).

A diversity of nearby aquatic sites and types of water (stream, tinajas, stock ponds of varying permanency, concrete drinkers and holding tanks, marshes and cienegas) is likely to enhance population persistence. Habitat diversity is important even within a single site. Springs and groundwater- (spring-) fed streams are likely to offer superior habitat qualities, especially against winter cold or periodic drought. Ranid frogs are sensitive to pollutants (Sparling 2003). As a result, populations persistence is likely greater in water that is not overly polluted by livestock feces or chemical pollutants (e.g., runoff from agricultural fields, roadside use of salts, aerial overspray).

Figure 3: Valley bottom cienega habitat, Empire Cienega, Las Cienegas National Conservation Area, Arizona. Photo by J. Rorabaugh.

Chiricahua leopard frogs are rarely found in abundance in natural montane settings in southern Arizona; rather they sometimes achieve high reproductive success and population density in constructed ponds in the mountains. The optimal setting appears to include a stream or tinaja-studded canyon within dispersal distance of suitable pond habitats. The ponds provide reproductive habitat, whereas natural waters provide either drought refugia, habitat complexity as a buffer against unpredictability, additional reproductive output, or a combination of some or all of these factors. Additional research is needed to examine this in more detail, as landscape

structure with perennial natural water and semi-perennial ponds poorly suited to non-native species or with perennial ponds not successfully reached by non-native species may be key to recovery of the species in montane settings.

Juvenile habitat requirements

The juvenile habitat requirements of Chiricahua leopard frogs are not well studied, but some spatial and temporal separation of adults and juveniles may enhance survivorship. Seim and Sredl (1994) studied the association of juvenile-adult stages and pool size in the closely related lowland leopard frog (*Rana yavapaiensis*) and found that juveniles were more frequently associated with small pools and marshy areas while adults were associated with large pools. Fernandez (1996) speculated that low juvenile survival in a captive colony of Chiricahua leopard frogs was due to lack of cover and cannibalism. Jennings (1988) noted that juveniles were more active during the day, while adults were more active at night.

Egg deposition sites

Females deposit spherical masses attached to submerged vegetation. Jennings and Scott (1991) found egg masses to be suspended within two inches of the surface attached to vegetation. Vegetation associated with egg masses included *Potamogeton* spp., *Rorippa* sp., *Echinochloa* sp., and *Leersia* sp. Zweifel (1968) found the minimum-maximum water temperatures for Chiricahua leopard frog embryos to be 53.6-88.7˚F. Zweifel reported the highest temperature at which an egg mass was found in the wild as 82.0˚F. In New Mexico, egg mass temperatures ranged from 54.7˚F, recorded from a stock tank at 7,825 feet elevation, to 85.1˚F, recorded at a warm spring at 6,185 feet (personal observations of R. Jennings, Technical Subgroup).

Home range size

Based on radio telemetry and mark/recapture data, male home range sizes (dry season mean = 1,733 feet^2: wet season, mean = 4,044 feet^2) tended to be larger than those of females (dry season mean = 614 feet^2; wet season mean = 992 feet^2). The largest home range size documented for the species was that of a male who used approximately 251,769 feet^2 (7,674 by 32 feet) of an intermittent, low elevation canyon (5,825 feet) in New Mexico during July and August 1999. Another male moved 2.2 miles in one direction during that same time period. The largest home range size documented for a female frog was about 102,258 feet^2 (3,116 by 32 feet). Male frogs tended to expand home range size to a greater degree than females when ranges during the dry season (early July) were compared to wet season (R. Jennings, C. Painter, Technical Subgroup, late July and August; personal observations).

Reasons for Listing/Threats

Overview

Recent articles in the scientific literature report the extirpation and extinction of amphibians in many parts of the world (Blaustein and Wake 1990, Pechmann *et al.* 1991, Vial and Saylor 1993, Laurence *et al.* 1996, Lips 1998, 1999, Berger *et al.* 1998, Houlahan *et al.* 2000, Stuart *et al.*

2004). A total of 1,856 species, or 32.5 percent of all amphibians, are globally threatened (on the IUCN Red List), and 43.2 percent are experiencing some form of population decrease (Stuart *et al.* 2004). In the United States, frogs in the family Ranidae, which includes the Chiricahua leopard frog, are particularly affected (Corn and Fogleman 1984, Hayes and Jennings 1986, Clarkson and Rorabaugh 1989, Bradford 1991, Drost and Fellers 1996, Sredl 1993, Bradford *et al.* 1994, Sredl *et al.* 1997, Jennings and Fuller 2004). These population declines result in many cases from habitat loss or predation by introduced species (Fernandez and Rosen 1996; Rosen *et al.* 1996a, 1994; Hayes and Jennings 1986); however, populations are sometimes extirpated from seemingly pristine habitats, often at higher elevation, montane locales (Hines *et al.* 1981, Corn and Fogleman 1984, Drost and Fellers 1996, Sredl 1993, Meyer and Mikesic 1998, Stuart *et al.* 2004). In the last few years, the role of infectious diseases has been recognized as a key factor in amphibian declines in seemingly pristine areas (Daszak *et al.* 1999, Carey *et al.* 2001, 1999). A fungal skin disease, chytridiomycosis (caused by the amphibian chytrid, *Batrachochytrium dendrobatidis*), has been linked to amphibian decline in many parts of the world (Berger *et al.* 1998, Speare and Berger 2000, Stuart *et al.* 2004), including the Chiricahua leopard frog in Arizona (Milius 1998, Sredl 2000, Sredl and Caldwell 2000) and New Mexico (Christman *et al.* 2003). A number of other factors have been identified as causes or possible causes of global amphibian decline; although their role in the declining status of the Chiricahua leopard frog is poorly studied or unknown, they may be contributing causal factors. These factors include climate change, pesticide or other contaminants, UV-B radiation, and potentially other stressors. Amphibian populations may persist in the face of some adverse environmental factors but may be lost under the cumulative effects of many pervasive threats. Furthermore, factors are likely working in synergy to exacerbate deleterious effects (Keisecker and Blaustein 1995, Vatnick *et al.* 1999, Carey *et al.* 2001, 1999; Keisecker *et al.* 2001, Middleton *et al.* 2001). Increased extirpation rates and in some cases extinction, coupled with recent declining trends in the status of many amphibian populations worldwide, are alarming and represent a very recent and rapid global decline of an entire class of vertebrates on all six continents on which they live (Carey *et al.* 1999, Blaustein *et al.* 1994, Wake 1991, Stuart *et al.* 2004).

Documented threats to the Chiricahua leopard frog were described in the final listing rule as they pertain to the five listing factors of the ESA (67 FR 40790) and are expanded upon herein. The five listing factors discussed in that rule include: A) the present or threatened destruction, modification, or curtailment of its habitat or range; B) overutilization for commercial, recreational, scientific, or educational purposes; C) disease or predation; D) the inadequacy of existing regulatory mechanisms; and E) other natural or manmade factors affecting its continued existence. Of these, threats associated with factor C are the most important to the Chiricahua leopard frog, including predation by non-native organisms, especially American bullfrogs, fish, and crayfish, and an often lethal, apparently introduced fungal disease (chytridiomycosis). Also of importance are degradation and loss of habitat as a result of water diversions and groundwater pumping, livestock management that degrades frog habitat, a history of fire suppression and grazing that has increased the likelihood of crown fires; mining; development; environmental contamination; disruption of metapopulation dynamics; and increased chance of extirpation or extinction resulting from small numbers of populations and the dynamic nature of frog habitats. These threats are described below.

Predation by Non-native Organisms (Listing Factor A, C, E)

Predation by introduced, non-native American bullfrogs, fishes, crayfish, and barred tiger salamanders (barred tiger salamanders – *Ambystoma tigrinum mavortium* – are introduced in southeastern Arizona and southwestern New Mexico, but *A. t. nebulosum* and *A. t. stebbinsi* are native elsewhere within the range of the Chiricahua leopard frog in Arizona and New Mexico) is implicated as a contributing factor in the decline of ranid frogs in western North America (Moyle 1973, Hayes and Jennings 1986, Bradford *et al.* 1993, Fernandez and Rosen 1996), and may be the most important factor identified so far in the current decline of the Chiricahua leopard frog (Rosen *et al.* 1994, 1996a). In southeastern Arizona, Rosen *et al.* (1994, 1996a) documented 13 non-native predaceous vertebrate species in aquatic communities in the range of the Chiricahua leopard frog, including American bullfrog, barred tiger salamander, and 11 fish species including largemouth bass (*Micropterus salmoides*), trout, and catfish. Although predation is probably the most important effect non-natives have on Chiricahua leopard frogs, they can also serve as disease vectors (see "Disease and Contaminants" below) and may compete with Chiricahua leopard frogs or alter their behavior (see review in Casper and Hendricks 2005). Servoss and Sharrocks (2005) documented a male American bullfrog in amplexus with a female Chiricahua leopard frog and suggested that reproductive interference may be among the effects bullfrogs have on Chiricahua leopard frogs and other native ranids.

Rosen *et al.* (1994, 1996a) found that Chiricahua leopard frogs were replaced by American bullfrogs and centrarchid fish. In the Chiricahua region of southeastern Arizona, 19 of 23 perennial waters investigated that lacked introduced predatory vertebrates supported Chiricahua leopard frogs. Thirty-one of 34 waters that supported introduced vertebrate predators lacked Chiricahua leopard frogs (Rosen *et al.* 1996a). At the three sites where Chiricahua leopard frogs occurred with non-natives (one site with green sunfish, *Lepomis cyanellus*, and two with tiger salamanders), either the frog or the non-native vertebrate was rare. In two of the three cases, frogs may have dispersed from nearby localities (Rosen *et al.* 1996a), and thus may have represented immigrants rather than a viable population.

In the San Rafael Valley, Arizona, Chiricahua leopard frogs were only found at sites that lacked non-native fishes and American bullfrogs (Snyder *et al.* 1996). In the White Mountains of Arizona, disappearance of Chiricahua leopard frogs from most historical localities correlated with the appearance of tiger salamanders and non-native crayfish (Fernandez and Rosen 1996, Fernandez and Bagnara 1995). Crayfish were found to prey upon Chiricahua leopard frog larvae, metamorphs, and adults. Crayfish recently spread to the breeding pond of one of the last and possibly the most robust populations of Chiricahua leopard frogs in the White Mountains, Arizona (USFWS files, Phoenix, AZ; Fernandez and Rosen 1998), and are now very abundant in former Chiricahua leopard frogs habitats on the Blue River, Arizona (J. Platz, pers. comm. 2000).

Sredl and Howland (1994) noted that Chiricahua leopard frogs were nearly always absent from sites supporting American bullfrogs and non-native predatory fishes. Bluegill sunfish, crayfish, bass, green sunfish, and carp (including koi, *Cyprinus carpio*) are particularly good predators on leopard frogs. However, Rosen *et al.* (1996a) suggested further study was needed to evaluate the effects of mosquitofish, trout, and catfish on frog presence. Rosen *et al.* (1996a) suspected that

catfish would almost always exclude Chiricahua leopard frogs, and that trout may exclude leopard frogs. Vredenburg (2004) demonstrated that introduced rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) were effective predators on mountain yellow-legged frog tadpoles (*Rana muscosa*), and that such predation was the most likely mechanism responsible for the decline of that frog. However, Zweifel (2006) observed both Chiricahua leopard frogs and trout (unknown species) in abundance at Herb Martyr Dam in the Chiricahua Mountains. Mosquitofish and Chiricahua leopard frogs can coexist; however, in at least in some circumstances (especially at high abundance of mosquitofish and/or low habitat diversity), predation by mosquitofish may greatly reduce larval frog survival. While tiger salamanders will prey upon leopard frogs, the two can coexist. Presence of tiger salamanders should not preclude recovery potential for leopard frogs, except perhaps in simple systems. In general, Chiricahua leopard frogs are more likely to coexist with non-native predators in habitats that provide habitat diversity and complexity, where shallow water, vegetation cover, and other features provide refuge from predators.

Interactions among non-natives may facilitate further invasion or dominance of non-native predators. In their native range, American bullfrogs have a positive association with centrarchid sunfishes (Werner and Peek 1994). From the results of field experiments in Oregon, Adams *et al.* (2003) showed that invasion by American bullfrogs is facilitated by presence of co-evolved bluegill. Survival of native dragonfly nymphs, which prey heavily on American bullfrog larvae, declined substantially in the presence of predation by bluegill. As densities of dragonfly nymphs declined due to predation, larval American bullfrog survival increased. However, in the Southwest, some native species, such as chubs, may have this same kind of effect, while others, such as largemouth bass, may tend to reverse it by preying on both American bullfrog tadpoles and bluegill (Rosen and Baker, *manuscript*).

The Rio Grande leopard frog (*Rana berlandieri*) is a recent introduction to southwestern Arizona and southeastern California (Platz *et al.* 1990). Although the species does not presently occur within the range of the Chiricahua leopard frog, it is rapidly expanding its distribution and currently occurs as far east as the Phoenix area (Rorabaugh *et al.* 2002). If it continues to spread eastward, the ranges of the Rio Grande and Chiricahua leopard frogs may overlap in the future. This large, introduced leopard frog might prey on small Chiricahua leopard frogs (Platz *et al.* 1990), and tadpoles of the two species may compete.

Fish introductions, mostly for sport and food, but also from aquaculture, aquarium releases, as additional forage, and for biological controls, have been common in the southwestern United States (Rinne 1995). For example, the number of fish species established in Arizona has almost tripled since the beginning of the 20th century as a result of the introduction of non-native fishes (Rinne 1991). Many of these introduced fishes are better adapted to the highly altered streams now found in the southwestern United States than are the native fishes (Rinne and Minckley 1991).

Native fishes of the Southwest have suffered a fate similar to that of native leopard frogs. High rates of endemism characterize native fishes from the southwestern United States where specialization of form is the rule rather than the exception (Rinne 1995). Fishes native to the southwestern United States are typically adapted to tolerate waters of high temperature or

salinity. They are also habitat specialists in areas such as thermal springs or highly erosive streams, and are typically better adapted to floods than non-natives (Minckley and Mefee 1987). While habitat specialization has enabled these fishes to persist in habitats few other species can withstand, it has left them vulnerable to habitat alterations and invasive species. As the human population has grown throughout the region and demand for water has intensified, aquatic ecosystems have been greatly altered (Kolar 2003). Numerous dams and intensive livestock grazing practices have changed water temperature and flow regimes, usually reducing habitat quality for native fishes (Rinne and Minckley 1991).

In contrast to non-native aquatic vertebrates, numerous species of native fishes, the Sonoran mud turtle (*Kinosternon sonoriense*), other species of native ranid frogs, and native garter snakes commonly coexist with the Chiricahua leopard frog (Rosen *et al.* 1996a, Platz and Mecham 1979). Tiger salamanders are native to the following portions of the Chiricahua leopard frog's range: San Rafael Valley in southeastern Arizona (*Ambystoma tigrinum stebbinsi*), the northern portion of the species' range (*Ambystoma tigrinum nebulosum*), and the mountains of Sonora, Chihuahua, and Durango (*Ambystoma rosaceum*). Native fishes, such as trout (*Oncorhynchus*), chub (*Gila*), longfin dace (*Agosia chrysogaster*), and topminnow (*Poeciliopsis*), also occur within the range of the Chiricahua leopard frog.

The spatial and ecological relationship between native Southwestern ranid frogs and native fishes has not been adequately studied. However, observations and laboratory feeding trials indicate that larger native fishes, especially chubs (*Gila* sp.) are active and effective predators on leopard frog tadpoles. In streams with chubs, tadpoles are often most abundant in shallows and pools with few or no chubs, or only small chubs. Native fishes such as longfin dace and topminnows appear most compatible with leopard frogs, whereas more predatory types like chubs seem much less compatible, although the abundance of these fish is likely important in determining their effects on leopard frogs. In addition, it is most often the case that the Chiricahua leopard frog is abundant in ponds and springs with no fish.

Laboratory studies indicate that native topminnows and longfin dace are not significant predators on leopard frog tadpoles (preliminary predator studies by P. Rosen, Technical Subgroup, 2004); however, their roles as competitors, or their indirect effects on leopard frog tadpole fitness through food web pathways have not been evaluated. Field observations are difficult because the topminnow now occurs in so few places, and the dace is primarily at lower elevations where the lowland leopard frog, rather than the Chiricahua leopard frog, successfully coexists with it.

Disease and Mining-Related Contaminants (Listing Factor A, C, D)

Postmetamorphic Death Syndrome (PDS) (Scott 1993) has been implicated in the extirpation of Chiricahua leopard frog populations in Catron County, New Mexico, as well as in other frog and toad species. All stock tank populations of the Chiricahua leopard frog in the vicinity of Gillette and Cooney tanks disappeared within a three-year period, apparently as a result of PDS (Scott 1993). The syndrome is characterized by death of all or nearly all metamorphosed frogs in a short period of time, leaving only tadpoles surviving in the population. Dead or moribund frogs were often found during or immediately following winter dormancy or unusually cold periods. The syndrome appeared to spread among adjacent populations causing regional loss of

populations or metapopulations. Similar die-offs or spring absence of frogs were noted in Arizona and Sonora. In some years, very few Chiricahua leopard frogs occurred in the canyons of the Santa Rita and Pajarito mountains in the spring, suggesting that frogs were dying during the winter months (67 FR 40790). The apparent post-metamorphic death of the Tarahumara frog was documented in southern Arizona and northern Sonora as early as 1974, and by 1983 this species had died out in Arizona (Hale 2001, Hale *et al.* 1995, Hale and Jarchow 1988).

Arsenic and or cadmium poisoning were contributing factors in these frog die-offs (Hale and Jarchow 1988). Arsenic often occurs at high levels near sulfitic mine tailings and may be leached by rainfall containing elevated levels of sulfate (Hale and Jarchow 1988). Cadmium originating from airborne emissions from copper smelters in southern Arizona and northern Sonora was identified as another possible cause of mortality. Frogs appeared to persist most consistently at springs and headwaters where cadmium to zinc ratios were relatively low, which is consistent with the theory that contaminants were washing into streams and accumulating in downstream reaches. Precipitation collected in 1984-5 in southeastern Arizona had a depth-weighted mean pH of 4.63 and carried high levels of sulfate, arsenic, cadmium, copper, lead, and zinc. High acidity and sulfate concentration occurred when upper-level winds were from the

Figure 4: Taken from the southern end of the Huachuca Mountains, a plume of light-colored smoky pollutants can be seen originating at the Cananea smelter in the upper left of the photo. The plume is blowing northwesterly (to the right) towards the Patagonia and Santa Rita mountains. Airborne pollutants from this and other smelters likely contributed to acidic rainfall and heavy metal deposition in Chiricahua leopard frog habitats in southern Arizona. The smelter closed in 1999. Photo by J. Rorabaugh.

directions of copper smelters, particularly those at Douglas, Arizona and Cananea, Sonora (Blanchard and Stromberg 1987). In regard to the northern leopard frog, waters no more acidic than pH 6.0 are optimal for fertilization and early development (Schlichter 1981). When exposed to waters of pH 5.5 for 10 days, 72 percent of northern leopard frogs died, versus a control group held in pH 7.0 that exhibited 3.5 percent mortality (Vatnick *et al.* 1999). These results suggest that precipitation may have been acid enough to affect Chiricahua leopard frog reproduction and survival. Small aquatic systems, such as stock tanks, that could be inundated by runoff during heavy rainfall events were most likely to be affected. Stock tanks with pHs of less than four were noted in the late 1990s on the western slope of the Huachuca Mountains, Arizona, which is near the smelter at Cananea (USFWS files, Phoenix, AZ). The smelters at Douglas and Cananea are now closed, thus we would expect a reduction or cessation of contaminant laden or acidic rainfall. The length of time it might take for residual elevated levels of cadmium, arsenic, and other smelter-related contaminants in the environment to disperse is unknown.

In the 1990s disease was recognized as a significant factor, if not the most important proximate factor, in global amphibian decline. In retrospect, the die-offs observed in New Mexico and attributed to "PDS" and die-offs of leopard frogs and Tarahumara frogs described above in Arizona and Sonora appear consistent with disease outbreaks elsewhere in the world. Lips (1998) documented reduced abundance and skewed sex ratios of two anuran species, and dead and dying individuals of six other amphibian species in Puntarenas Province, Costa Rica. Her observations were consistent with a pathogen outbreak and additional work indicated the fungal skin disease – chytridiomycosis - was likely responsible for the declines (Longcore *et al.* 1999, Berger *et al.* 1998). Lips (1998) noted that declines in her study area were similar to those reported for Monteverde, Costa Rica, the Atlantic coast of Brazil, and Australia. Amphibian decline in these areas spread wave-like across the landscape, suggestive of pathogen dispersal. Further work by Berger *et al.* (1998) showed that amphibian chytrid fungi were associated with amphibian declines in Panama and Queensland, Australia; the authors hypothesized it is the proximate cause of amphibian decline in these areas. Evidence now suggests chytridiomycosis is responsible for observed declines of frogs, toads, and salamanders in portions of Central America (Panama and Costa Rica), South America (Atlantic coast of Brazil, Ecuador, and Uruguay), Australia (eastern and western States), New Zealand (South Island), Europe (Spain and Germany), Africa (South Africa, "western Africa", and Kenya), Mexico (Sonora), and United States (8 States) (Berger *et al.* 1998, Longcore *et al.* 1999, Speare and Berger 2000, Hale 2001). Anuran populations in upland tropical riparian habitats are most affected. In Central America, such populations typically decline rapidly (4-6 months), more than 50 percent of species are extirpated, and remaining species persist at roughly 20 percent of former abundance (Lips *et al.* 2006). The proximal cause of extinctions of two species of Australian gastric brooding frogs (the only species in the family Rheobatrachidae), and the golden toad (*Bufo periglenes*) in Costa Rica was likely chytridiomycosis. Another species in Australia for which individuals were diagnosed with the disease may now be extinct (Daszak 2000).

Chytridiomycosis is a highly virulent fungal pathogen of amphibians capable of causing sporadic deaths in some populations, and 100 percent mortality in other populations. Surviving individuals may be carriers. The inoculating dose is low; 100 zoospores are able to cause clinical chytridiomycosis within four weeks. Some species appear highly susceptible to developing the

disease, progressing to death, while other species appear less susceptible to disease manifestations. In Arizona, chytridiomycosis has been reported from four populations of Chiricahua leopard frogs. Four populations of the Ramsey Canyon leopard frog have also been infected. Near Hurley, New Mexico, chytridiomycosis was the likely cause of decline and perhaps extirpation of populations in West Lampbright, Main Rustler, West Rustler, and Martin canyons (personal observations of R. Jennings, Technical Subgroup, 2004). Retrospective analysis of Tarahumara frog specimens collected during a die-off in Sycamore Canyon, Arizona in 1974 show they were infected with amphibian chytrids (based on histological examination by T.R. Jones and P.J. Fernandez, Grand Canyon University, Phoenix, Arizona, 2001), and the disease has now been confirmed from all Tarahumara frog declines and extirpations in Arizona and Sonora where specimens have been available for examination (Hale 2001, Hale *et al.* 2005). Recently, chytridiomycosis was confirmed from a 1972 *Rana yavapaiensis* specimen collected in Sycamore Canyon, two years before Tarahumara frog declines were first noted. This is the earliest record of a chytrid-positive anuran in the United States (Cashins *et al*. in press). Although chytridiomycosis has been associated with Southwestern ranid frog declines and extirpations, the role of the fungi in the larger picture of frog population dynamics is as yet undefined. It is clear that Chiricahua leopard frog populations can coexist with the disease for extended periods. The frog has coexisted with chytridiomycosis in Sycamore Canyon, Arizona since at least 1972. However, at a minimum, it is an additional stressor, resulting in extirpations in some cases or in periodic die-offs that increase the likelihood of extirpation and extinction.

Hale and Jarchow's (1988) contention that contaminants associated with copper smelters may have contributed to the die-offs should not be dismissed entirely, as many other environmental factors or stressors may interact with chytridiomycosis synergistically to either increase the virulence of the disease or compromise the immune systems of amphibians (Lips 1999). These factors or stressors may include increased levels of contaminants (such as cadmium, arsenic, pesticides and others), as suggested by Hale and Jarchow (1988, also see Parris and Baud 2004), but also acidic rainfall, climate or microclimate (e.g. temperature, moisture) change, cold winters, increased UV-B radiation, or other changes in habitats that cause stress and immunosuppression (Carey *et al.* 1999, 2001; Hale *et al.* 2005; also see "Global Climate Change, Pesticides and Other Non-Mining-related Contaminants, UV-B Radiation, and Other Stressors" below).

Epizootiological data (including high mortality rates, wave-like spread of declines, wide host range) from Central America and Australia suggest introduction of the disease into naive populations and the disease subsequently becoming enzootic in some areas (an enzootic disease is constantly present in an animal population, but usually only affects a small number of animals at any one time). Alternatively, the fungus may be a widespread organism that has emerged as a pathogen because of higher virulence or an increased host susceptibility caused by factors such as environmental changes (Berger *et al.* 1998), including changes in climate or microclimate, contaminant loads, increased UV-B radiation, or other factors that cause stress (Pounds and Crump 1994; Carey *et al.* 1999, 2001; Daszak 2000). Morehouse *et al.* (2003) found low genetic variability among 35 amphibian chytrid strains from North America, Africa, and Australia, suggesting that the first hypothesis – that it is a recently emerged pathogen that has dispersed widely – is accurate. If this is the case, its rapid colonization could be attributable to humans. The fungus does not have an airborne spore, so it must spread via other means. Amphibians in

the international pet trade (Europe and USA), outdoor pond supplies (USA), zoo trade (Europe and USA), laboratory supply houses (USA), and species recently introduced (*Bufo marinus* in Australia and American bullfrog in the USA and Uruguay) have been found infected with amphibian chytrids suggesting human-induced spread of the disease (Daszak 2000, Mazzoni *et al.* 2003). Recently, retrospective analysis revealed presence of chytridiomycosis in African clawed frogs (*Xenopus laevis*) dating to 1938 (Weldon *et al.* 2004). Further evidence showed the disease was a stable endemic in southern Africa for at least 23 years before any chytrid-positive amphibian specimen was found outside of that region. African clawed frogs were exported from Africa for use in human pregnancy testing beginning in the 1930s. Weldon *et al.* (2004) suggest that Africa is the origin of the disease and that international trade in African clawed frogs was the means of disease dissemination.

Once introduced to the Southwest via escaped or released clawed frogs, the disease may have spread across the landscape by human introductions or natural movements of secondarily-infected American bullfrogs, tiger salamanders, leopard frogs. Free-ranging healthy American bullfrogs with low-level chytridiomycosis infections have been found at Cienega Creek, Arizona (Bradley *et al.* 2002). These and other frogs may serve as disease vectors or reservoirs of infection (Bradley *et al.* 2002). Some native anurans, such as tiger salamanders (*Ambystoma tigrinum*), western chorus frogs (*Pseudacris triseriata*) and canyon treefrogs (*Hyla arenicolor*) contract the disease, but appear to persist in good numbers where ranid frogs have disappeared. These species may serve as reservoirs for the disease, or could spread the disease via movements among drainages or ponds (Carey *et al.* 2003, Collins *et al.* 2003). American bullfrogs are likely an important vector, owing to their mobility (Suhre *et al.* 2005) and apparent resistance to the disease (Daszak *et al.* 2004). A fish and a Ditiscid beetle have recently been found to test positive for chytrids in Arizona (R. Rettalick, discussion with J. Rorabaugh, 2005), and in Australia amphibian chyrid has been found on freshwater shrimp (Rowley *et al.* 2006). Other vertebrates or invertebrates may also act as vectors or reservoirs for the disease. Johnson and Speare (2005) demonstrated that amphibian chytrid can grow on bird feathers and survive 1-3 hours drying, suggesting the disease could be spread by waterfowl or other water birds moving among wetlands. It is not known whether populations of tiger salamanders or other potential vectors can harbor the chytrid fungus for long periods of time without ranid frogs to act as disease reservoirs. It is recognized that leopard frogs can carry the disease, without dying, especially during the short-term and during warm seasons. Thus, if a leopard frog population is open to uncontrolled immigration from other areas where infected leopard frogs (or American bullfrogs) exist, disease processes may play a paramount role in whether the leopard frogs remain abundant or are able to persist.

Chiricahua leopard frogs appear able to survive this disease process, but the mechanism is unknown. Exposure to temperatures of 90º F kills 100 percent of chytrids in 96 hours (Johnson *et al.* 2003); thus, warm springs may be among the most critical refugia for leopard frogs. The growth and activity of the fungus may also be halted at high pH (above 8, Piotrowski *et al.* 2004, Johnson and Speare 2005), which is not uncommon in Southwestern aquatic systems. Generally, higher colder waters are likely to make the frogs most susceptible to chytridiomycosis, whereas lower warmer waters and shorter warmer winters are likely better for the frogs.

In captivity, frogs can be cleared of chytridomycosis with the antifungal agents miconazole and itraconazole (Nichols and Lamirande 2003), but no methods currently exist to clear the disease from a habitat site and subsequently keep it free of disease. Innate defenses, such as anti-microbial peptides secreted into the skin's mucous layer, may be important for resistance to chytridiomycosis. Anurans possess different mixes of anti-microbial peptides, which vary in their effectiveness against amphibian chytrids and may help explain differing susceptibility among species (Rollins-Smith and Conlon 2004). Bacteria on the skin of some amphibians also provide some protection from amphibian chytrids (Harris *et al.* 2006). Frogs may develop resistance to the pathogen or the pathogen may have developed less virulent strains that do not drive the host species to extinction (Retallic *et al.* 2004). Mendelson III *et al.* (2006) suggest that natural agent control (such as anti-microbial peptides or cutaneous bacteria) or selecting for disease resistance may be be possible as recovery strategies for some amphibians currently at risk due to the disease. It is also possible that the disease may not be able to persist in the environment absent an amphibian host. If that is the case, perhaps at sites where Chiricahua leopard frogs have disappeared, after a period of time frogs could be successfully reestablished. Similarly, the disease organism cannot survive complete drying, so if a stock tank or other aquatic site dries out, the amphibian chytrid population may not persist, clearing the way for successful reestablishment projects. However, many attributes of the fungus and the disease in the wild are unknown, including reasons for death of hosts, survival of the fungus in the absence of amphibian populations, methods of transmission and spread, and place and time of origin. Much more work is needed before the threat posed by chytridiomycosis can be more thoroughly addressed.

Another amphibian disease, *Ambystoma tigrinum* virus, was found recently in a tiger salamander at a Phoenix bait shop. Because tiger salamanders also carry chytridiomycosis (Collins *et al.* 2003), use of waterdogs for bait has the potential to spread amphibian chytrid. Humans probably distribute the pathogen in many ways (Carey *et al.* 2003). For example, chytrids could be spread by tourists or fieldworkers sampling aquatic habitats (Halliday 1998). The fungus can exist in water or mud and thus could also be spread by wet or muddy boots, vehicles, cattle, and other animals moving among aquatic sites, or during scientific sampling of fish, amphibians, or other aquatic organisms.

Other Potential Infection Agents (Listing Factor A, C)

A number of other diseases and parasites could potentially affect Chiricahua leopard frog populations. Although relatively few have been documented to date in Chiricahua leopard frogs, studies of occurrence in this species are few and the importance of diseases in global amphibian decline warrants discussion of these potentially important infectious agents. The following is modified from Crawshaw (1997), Faeh *et al.* (1998), and references therein.

As evidence is collected for declines of amphibian populations worldwide, there is increased awareness of the effect of infectious and non-infectious disease on fitness, reproductive success and survival (Bradford 1991, Carey 1993). Infectious diseases of amphibians can be important indicators of stress and environmental mismanagement. To determine the causes of a major mortality event, a declining population, or the death of a single amphibian, one must be aware of the techniques necessary to obtain, preserve, and test diagnostic specimens. Detailed

examinations of multiple specimens are needed to determine if an outbreak of illness is due to a given etiologic agent. Because of the small size of many amphibians, specimens obtained may be depleted rapidly and therefore it may be necessary to collect additional individuals to perform the necessary tests. Healthy specimens and specimens that appear to be ill but are still alive are the best sources for comparative information.

Viruses

An increasing number of viruses are being identified in amphibians worldwide, but studies of their effect upon the host have been limited. There is mounting evidence that die-offs in local amphibian populations have been caused by viral infections. Viruses should be considered in any disease investigation, even if more apparent causes such as bacteria are identified. Viruses themselves may suppress immune function leading to death from bacterial disease. Viral infections may be overlooked unless thorough investigations are performed. Numerous iridoviruses, including Polyhedral Cytoplasmic Amphibian Virus (PCAV), Tadpole Edema Virus (TEV), and Frog Erythrocytic Virus (FEV) are known to cause mortality in anurans.

A ranavirus was recently confirmed in a dead Chiricahua leopard frog from the Deep Creek Divide area of New Mexico (R. Jennings, Technical Subgroup, 2004, personal observation). Ranavirus has killed large numbers of common frogs (*Rana temporaria*) in the United Kingdom and Scotland. Bullfrogs and goldfish are likely vectors, but ranaviruses have been isolated from a range of amphibian, fish, and reptile hosts in America, Europe, Australia, and Asia. *Ambystoma tigrinum* virus (ATV), a ranavirus that affects tiger salamanders, has been documented widely in western North America (Carey *et al.* 2003, Collins *et al.* 2003). Northern leopard frogs from Canada that were injected with ATV virus died, but the geographic extent of this or other ranaviruses and their potential effects on the Chiricahua leopard frog are unknown and need further investigation. A novel strain of ATV, such as might be introduced with waterdogs used as bait, could cause adverse effects to ranid frogs (J. Collins, Arizona State University, and J. Rorabaugh, 2005, telephone conversation).

Bacteria

There is an increasing number of reports of amphibian mortality associated with bacteria in North America and elsewhere. Due to their ubiquitous presence in the environment, bacteria are a major cause of morbidity and mortality in amphibians. The bacterial disease red leg, also called bacterial dermatosepticemia, is usually associated with the genus *Aeromonas* and other gram-negative and occasionally gram-positive bacteria; it has been widely recognized in wild amphibians, but many of these reports do not rule out an underlying primary stressor. The bacteria that cause red leg are normal inhabitants of frog environments and frogs may only become symptomatic when immune competence is compromised (Crawshaw 1992, Taylor *et al.* 2001). Symptoms of red leg in wild amphibians include pinpoint hemorrhages on the skin, especially abdomen, hind legs, and tail. Edema, skin ulceration, and ocular lesions may also be seen. Affected animals show the typical signs of lethargy and poor coordination. They may not be active feeders, and tadpoles may lie on the bottom of the pond or remain unresponsive close to the surface, rendering them susceptible to predation. Chiricahua leopard frogs found during die-offs frequently exhibit signs of red leg; however, other agents, such as iridovirus, chytridiomycosis, and chemical irritants, can cause similar gross signs. Cause of death can only

be determined by a thorough necropsy that includes microbial and viral isolation efforts, evaluation for presence of fungi and parasites, and histopathology.

Other bacteria histologically indistinguishable from red leg may also cause septicemia characterized by erythema and hemorrhages. The bacteria *Acinetobacter*, *Streptococcus*, *Pseudomonas*, *Citrobacteria*, *Mima*, and *E. coli* have all been identified in amphibian disease. *Salmonella*, *Leptospira*, and other potentially pathogenic bacterial have been isolated from healthy amphibians worldwide without signs of disease (Taylor *et al.* 2001).

Chlamydia - *Chlamydophila pneumoniae* has caused mortality in zoo and laboratory frogs, including the endangered Wyoming toad, *Bufo baxteri*. There is one report of the infection in a free-ranging Australian frog (Berger *et al.* 1999).

Cyanobacteria - Toxins produced by cyanobacteria could also cause die-offs in certain amphibian populations. This group of bacteria, formerly known as blue-green algae, produces potent toxins known to kill large animals. Increases in nitrogen and phosphorus in water in association with warm temperatures and favorable pH promote blooms of cyanobacteria.

Fungi

Chytridiomycosis, described above, is known to infect and cause die-offs of Chiricahua leopard frogs. Other fungal diseases, including Chromomycosis, Saprolegniasis, and Phycomycosis are also fungal diseases known to cause mortality in amphibian populations. Chromomycosis is characterized by ulcerative or granulomatous skin lesions and/or disseminated granulomas on internal organs. The causative organisms are a group of naturally-pigmented saprophytic fungi that are distributed worldwide. Signs of this fungus often include papular and ulcerative skin lesions on the ventral surface of the animal. Internally, the fungi primarily affect the liver, kidneys, and lungs that appear enlarged and contain gray-black nodules. Transmission of the fungi most likely occurs via environmental contact rather than contact between infected and non-infected frogs.

Saprolegniasis is a disease of aquatic amphibians caused by a wide range of water-borne fungal organisms. The presence of this disease often is secondary to other stressors, such as concurrent bacterial infections or trauma. Gross lesions appear as opaque, cottony growth on the skin and/or gills or spiracles. It can also infect frog egg masses and quickly disrupt the integrity of an egg mass.

Phycomycosis is caused by saprophytic organisms in the family Zygomycetes, which includes members of the *Absidia*, *Mucor*, *Rhizopus*, and *Basidiobolus* genera. Lesions resemble those seen with Chromomycosis.

Protozoans

Many of the familiar protozoan parasites of other vertebrates have also been recognized in amphibians. Flagellates are commonly found in the intestinal tract but some, notably the diplomonads, may invade the blood and other organs. Heavy infections may be pathogenic. Ciliates and the multinucleated opalinids may be found in the gastrointestinal tract of almost all

amphibians, but symptoms of disease are rare. Nyctotherids and balantidia are the most frequently found intestinal ciliates.

Coccidia – The intestinal coccidians of amphibians have been poorly described. Coccidia of all species including Amphibians are usually very host-specific and pathogenic only in heavy infections. They are unlikely candidates for agents of disease or mass mortality in amphibians.

Trypanosomes – Hemoflagellates, such as trypanosomes, are transmitted to amphibians by invertebrate intermediate hosts and vectors, such as leeches. It is thought that leeches infect tadpoles and salamander larvae, while mosquitoes infect adults. Infected animals develop degenerated erythrocytes, become debilitated and anorexic, and subsequently die. These blood protozoans are generally considered to be non-pathogenic in their natural hosts.

Metazoans

Goldberg *et al.* (1998) identified six species of Trematoda and at least one species of Nematodes from the organs of 25 specimens of Chiricahua leopard frog collected from Arizona. No other study has examined parasites in Chiricahua leopard frogs. It is unlikely that parasitic diseases are having a serious impact on amphibian populations. Heavy parasite loads can affect growth rates and survivability, but the effects are usually seen in young.

Myxosporea - Developmental and mature stages of myxosporeans have been found in the tubules and glomerular spaces of the kidneys of ranid frogs. Myxosporeans are usually considered non-pathogenic to the host, although it is conceivable that heavy infections could affect renal function and hence survivability.

Nematodes – Nematode infections are generally found in the lungs and intestines of anurans; larvae may be found in various tissues.

Trematodes – Intermediate stages (metacercariae) may be found in the skin, musculature, intestinal walls, kidneys, and other tissues of frogs and tadpoles throughout the world. Inflammatory cells and fibrosis surround some cysts. In heavily infected frogs, there is considerable reduction of functional renal tissue, although no deleterious effects have been described. Flukes have been found in the lungs, musculature, and other tissues in frogs. Significant mortality was attributed to Monogenean flukes, which are common parasites of the skin of amphibians and fish, in a group of wild-caught American bullfrogs.

Infections of a parasitic trematode (*Ribeiroia* sp.) have been implicated in limb malformations of Pacific treefrogs (*Pseudacris regilla* Complex) in California, and may be a contributing factor in malformations observed in other amphibians (Johnson *et al.* 1999), including northern leopard frogs in Arizona (Sessions *et al.* 1999). However, Gilliland and Muzzall (1999, 2002) concluded that trematodes were not the cause of deformities in southern Michigan. Visiting the "hottest of the Minnesota malformed frog hotspots," and control sites, Lannoo *et al.* (2000) concluded that where *Ribeiroia* metacercariae were found, they likely cause malformations, but there were two important disconnects: some "control" sites contained *Ribeiroia*, but malformations were not present in high numbers; at some "hotspots," malformations were present in the absence of *Ribeiroia* metacercariae. We are not aware of limb malformations in wild Chiricahua leopard

frogs, although some captively-reared or headstarted frogs in Arizona are sometimes missing limbs or digits, or have multiple limbs. The causes of these limb malformations have not been investigated.

Leeches – Leeches commonly feed on many amphibians in North America. Heavy infestations may cause dermal ulceration with hemorrhage around the point of attachment to the skin. Such lesions may become the portal of entry of bacterial and other microorganisms. Aquatic leeches are vectors of blood-borne parasites of amphibians. Trypanosomes and other hematozoa are transmitted by leeches and it is also possible that viral infections are spread by the same method.

Degradation and loss of habitat (Listing Factor A, D)

Historical Perspective

Riparian (in or associated with wetted areas) and wetland communities throughout the range of the Chiricahua leopard frog are much altered and/or reduced in size compared to early- to mid-19th century conditions (Minckley and Brown 1982, Hendrickson and Minckley 1984, Brown 1985, Arizona Department of Water Resources 1994). Dams, diversions, stream channelization, groundwater pumping, introduction of non-native organisms, woodcutting, mining, contaminants, urban and agricultural development, road construction, grazing by livestock and elk, and altered fire regimes have all contributed to reduced quality and quantity of riparian and wetland habitat (Gifford and Hawkins 1978, Arizona State University 1979, Hendrickson and Minckley 1984, Brown 1985, Bahre 1995a, Hadley and Sheridan 1995, Hale *et al.* 1995, Ohmart 1995, Stebbins and Cohen 1995, DeBano and Neary 1996, Belsky and Blumenthal 1997, Wang *et al.* 1997).

Many of these changes began before ranid frogs were widely collected or studied in Arizona and New Mexico. The Chiricahua leopard frog may have been much more widely distributed in pre-settlement times than is indicated by historical collections. Extant localities are generally located in stream and river drainage headwaters, springs, and stock tanks. However, historical records exist for the Verde, San Pedro, Santa Cruz, and Gila rivers, and the species is extant in the San Francisco and Mimbres rivers in New Mexico and on the Blue River in Arizona. This suggests that the species may have occurred in other major drainages such as the mainstems of the Salt, White, Black, and Little Colorado rivers. The Chiricahua leopard frog is also now largely absent from valley bottom cienega complexes in southeastern Arizona, which likely contained large populations historically. Habitat degradation, diversions, loss or alteration of stream flows, groundwater pumping, introduction of non-native organisms, and other changes are often most apparent on these larger drainages and cienega complexes (Hendrickson and Minckley 1984, Sredl *et al.* 1997, State of Arizona 1990).

Although the cumulative effect of such changes to its habitat is unknown, the extirpation of the Chiricahua leopard frog may have occurred in some major drainages and cienegas prior to its occurrence being documented. Large drainages connect many of the extant and historical populations and may have served as important corridors for dispersal and exchange of genetic material. Riverine and cienega populations probably served as sources of frogs for recolonization if extirpations occurred within satellite populations (Rosen *et al.* 1996a, Sredl *et al.* 1997).

Beavers (*Castor canadensis*) likely promoted the creation of Chiricahua leopard frog habitat. The activities of beavers tend to inhibit erosion and downcutting of stream channels (Parker *et al.* 1985) and ponded water behind beaver dams is favored habitat for ranid frogs. However, beavers were extirpated from some areas by the late 1800s and are still not abundant or are extirpated from other areas where they were once common (Hoffmeister 1986). For example, in Arizona beavers are extirpated from the Santa Cruz River and, before recent reestablishments, were extirpated from the upper San Pedro River. Loss of this mammal and their constructed dams likely resulted in loss of backwaters and pools favored by the Chiricahua leopard frog.

These changes occurred before leopard frogs were widely collected; thus, hypotheses concerning correlations between extirpations of beaver and Chiricahua leopard frogs cannot be tested by comparing historical versus extant frog populations. Where beavers occur within the range of the Chiricahua leopard frog today, beaver ponds are often inhabited by non-native predators, such as introduced fishes and American bullfrogs that prey upon and preclude viable populations of Chiricahua leopard frogs. Because non-native species often thrive in beaver ponds, the presence of beavers and the ponds they construct could now actually hinder recovery of the Chiricahua leopard frog in some systems.

Livestock Grazing

Livestock grazing is the most widespread land management practice in western North America (Fleischner 1994). Although livestock influences on the rangelands of the Southwest were not significant until late into the 18th century, livestock were effectively introduced into the area in 1539 when Francisco Vazquez de Coronado voyaged into Arizona trailing cattle, sheep and horses (Hastings and Turner 1965). Oñate's colonization of New Mexico in 1598 was accompanied by the first livestock introductions in that state. Completion of the railroads in the 1880s coupled with suppression of Apache raids on ranchers allowed large-scale interstate commerce in livestock and a much greater demand for cattle from Arizona and New Mexico. By 1888 there were approximately 8.9 million cattle in New Mexico (Wilderman and Brock 2000). In 1610, 100,000 cattle ranged the grasslands of the San Pedro and Bavispe rivers in Arizona-Sonora; and by 1891 an estimated 1.5 million cattle were present in Arizona (Hastings and Turner 1965). With the increased demand for beef, ranchers moved large numbers of cattle onto open rangeland with minimal regard for grazing management. The decline of the industry was a result of heavy overgrazing coupled with a severe drought in the early 1890s followed by heavy rains, erosion, and arroyo cutting (Hendrickson and Minckley 1984, Kruse and Jemison 2000). The early cattle industry was both a cause and a result of severe ecosystem degradation, resulting from several interacting factors, including overstocking of rangelands, decrease in plant vigor and cover, drought, suppression of natural fires, and removal of beaver along streams (Tellman *et al.* 1997).

Intense livestock grazing during the late 1800s and early 1900s was likely a key cause of change in the structure and composition of montane forests, arroyo cutting and loss of cienegas and riparian systems, replacement of grasslands by shrublands, and altered fire regimes (Hendrickson and Minckley 1984, Swetnam and Baisan 1996), although other factors such as logging, mining, loss of beaver populations, and climate change also likely contributed (Hereford 1993, Bahre 1995a and b, Geraghty and Miller, Inc. 1995). The effects of livestock grazing on leopard frog populations are not well-studied. Livestock are adapted to mesic habitats and select riparian

habitats for water, shade, and cooler temperatures. They spend a disproportionate amount of their time in riparian zones and can adversely affect these systems in a number of important ways (see Fleischner 1994, Belsky *et al.* 1999, Jones 2000, and references therein).

Livestock grazing is nearly ubiquitous within the historical range of the frog. The Chiricahua leopard frog coexists with grazing activities at most sites where it is found. In fact, stock tanks, constructed as water sources for livestock, are important habitats for the Chiricahua leopard frog, particularly in Arizona (Sredl and Saylor 1998, Sredl and Jennings 2005). In some areas, stock tanks replaced natural springs and cienegas or were developed at spring headwaters or cienegas and now provide the only suitable habitat available to the Chiricahua leopard frog. For instance, the only known localities of the Chiricahua leopard frog in the San Rafael and San Bernardino valleys, Buckskin Hills, and in the Patagonia Mountains of Arizona are stock tanks. In Arizona, Sredl and Saylor (1998) found a significantly higher proportion (62 percent) of known extant populations in stock tanks as compared to those in riverine habitats (35 percent), suggesting Arizona populations of this species have fared better in stock tanks than in natural habitats. However, this generalization does not hold for New Mexico, where in recent years many stock tank populations were extirpated, apparently by disease (Painter 2000). Sredl and Saylor (1998) found that stock tanks in Arizona are occupied less frequently by non-native predators (with the exception of American bullfrogs) than natural sites. For all these reasons, there is a high probability that the Chiricahua leopard frog would be extirpated from many more areas if ranchers had not built and maintained stock tanks for livestock production.

Although stock tanks provide refugia for frog populations and are important for this species in many areas, only small populations are supported by such tanks and these habitats are very dynamic and lack habitat complexity. Tanks often dry out during drought, and flooding may destroy downstream impoundments or cause siltation, either of which may result in loss of aquatic communities and extirpation of frog populations. Construction of tanks may destroy natural habitats at or downstream of the tank, and may alter local hydrology. Periodic maintenance to remove silt from tanks may also cause a temporary loss of habitat and mortality of frogs. Populations of non-native introduced predaceous fishes, American bullfrogs, and other species, although less prevalent than in natural habitats, sometimes become established in stock tanks and are implicated in the decline of the Chiricahua leopard frog (Rosen *et al.* 1994, 1996a). Stock tanks may facilitate spread of infectious disease and non-native aquatic organisms by providing aquatic habitats in arid landscapes that otherwise may have served as barriers to the spread of such organisms. Most stock tanks do not provide suitable breeding habitat because they do not regularly hold water long enough for development of larvae to metamorphosis. Sredl and Saylor (1998) caution that stock tank populations are sometimes simply mortality sinks with little reproduction or recruitment.

Other adverse effects to the species and its habitat may occur under certain circumstances as a result of livestock grazing activities (Sredl and Jennings 2005). These effects include trampling of eggs, tadpoles, and frogs; deterioration of watersheds; erosion and/or siltation of stream courses; elimination of undercut banks that provide cover for frogs; loss of wetland and riparian vegetation and backwater pools; and spread of disease and non-native predators (Arizona State University 1979, Hendrickson and Minckley 1984, Ohmart 1995, Jancovich *et al.* 1997, Belsky *et al.* 1999, Ross *et al.* 1999, U.S. Fish and Wildlife Service 2000, Sredl and Jennings 2005).

Increased watershed erosion caused by grazing can accelerate sedimentation of deep pools used by frogs (Gunderson 1968). Sediment can alter primary productivity and fill interstitial spaces in streambed materials with fine particulates that impede water flow, reduce oxygen levels, and restrict waste removal (Chapman 1988). Eggs, tadpoles, metamorph frogs, and frogs hibernating at the bottom of pools or stock tanks have the potential to be trampled by cattle (Bartelt 1998, Ross *et al.* 1999, U.S. Fish and Wildlife Service 2000).

Trampling of Chiricahua leopard frogs by cattle has not been documented; however, it likely occurs. Working in Nye County, Nevada, Ross *et al.* (1999) found a dead adult Columbia spotted frog (*Rana luteiventris*) in the hoof print of a cow along a heavily grazed stream. They observed numerous other dead frogs in awkward postures suggesting traumatic death, likely due to trampling. In Idaho, Bartelt (1998) documented near complete loss of a metamorph cohort of boreal toads (*Bufo boreas*) due to trampling by sheep at a livestock tank. Juvenile and adult frogs can probably often avoid trampling when they are active; however, leopard frogs are known to hibernate on the bottom of ponds (Harding 1997), where they may be subject to trampling during the winter months.

In June 1994, a die off of Chiricahua leopard frogs occurred at a stock tank in the Chiricahua Mountains, Arizona, that reduced the frog population from 60-80 adults to fewer than 10 (Sredl *et al.* 1997). Analysis of dead and moribund frogs and water from the tank indicated that disease was unlikely to be the cause of the die off; however, levels of hydrogen sulfide were high enough to be toxic to wildlife. The authors suspected that high detritus loads (including cattle feces), low water levels, high water temperature, and low concentrations of dissolved oxygen created a suitable environment for sulphur-producing bacteria that produced toxic levels of hydrogen sulfide. Chiricahua leopard frogs have not been found at this site since 1994.

Grazing by Elk

In some locations, elk populations along the Mogollon Rim of Arizona and into New Mexico are causing riparian habitat degradation similar to that of livestock. Both cattle and elk can damage riparian habitats and both tend to gather near water during dry periods, at which time riparian damage is most apparent. Due to the cumulative effects of continued grazing by cattle and elk in central Arizona and west central New Mexico and other anthropomorphic stresses, riparian areas have been deemed the most damaged and threatened ecosystem in the Southwest (Fleischner 1994, Catron *et al.* 2000). State Game and Fish agencies have taken steps to increase elk harvests where resource damage is occurring.

Dams and Reservoirs

Many large impoundments or lakes were created within the range of the Chiricahua leopard frog for water storage, recreation, and as a source of hydroelectric power. For instance, historical records exist for the species from Luna Lake, Nelson Reservoir, Hawley Lake, and Rainbow Lake north of the Gila River in Arizona; and Lake Roberts, Patterson Lake, and Ben Lilly Lake in New Mexico, but surveys at these sites since 1985 did not locate Chiricahua leopard frogs (Arizona Game and Fish Department 1997, Painter 2000). Currently, large impoundments invariably support populations of predaceous non-native fishes, crayfish, and/or American bullfrogs. Predation and possibly competition with leopard frogs by these introduced predators likely caused or contributed to the disappearance of the Chiricahua leopard frog from reservoirs.

Creation of reservoirs is not the direct cause of the loss of Chiricahua leopard frog populations. However, the stable, deep water they provide is excellent habitat for sport fisheries, crayfish, and bullfrogs. A long history of State, Tribal, and Federal stocking programs, combined with "bait bucket" introductions have rendered these aquatic sites largely unsuitable for leopard frogs. In some cases, such as high altitude lakes, if stocking ceased, non-native fish populations might disappear due to lack of reproduction. In those cases, there may be opportunities for restoration of native fish and frog populations.

Construction and operation of reservoirs also alter downstream flows and can result in dramatic changes in stream hydrology, rates of erosion and sedimentation, riparian vegetation, and other components of riparian ecosystems (Johnson 1978). The effects of these changes on Chiricahua leopard frog populations are unknown. However, downstream effects of such impoundments are implicated in the decline of other anurans, including the endangered arroyo toad (*Bufo californicus*, 59 FR 64859) and the foothill yellow-legged frog (*Rana boylii*, Lind *et al.* 1996).

Below a dam on the Trinity River in California, the extent of riparian vegetation increased with an accompanying decrease in sandbars (breeding habitat of the yellow-legged frog). Unseasonably high-flows from dam releases also resulted in loss of entire cohorts or age groups of larval frogs (Lind *et al.* 1996). Similar effects may occur in Chiricahua leopard frog habitats. Water temperatures are often colder below dams than in similar unaltered systems (Lind *et al.* 1996), which may retard development of frog eggs and larvae (Stebbins and Cohen 1995) or increase susceptibility to chytridiomycosis (Carey *et al.* 1999). Lack of scouring flood flows below dams may also create relatively stable pools with abundant vegetation that favors establishment of American bullfrogs (Lind *et al.* 1996) and non-native fishes. In some cases, dams may have created more stable or perennial flows in downstream reaches, which were historically unsuitable for Chiricahua leopard frogs. However, these reaches now almost invariably support non-native predators. Dispersal of non-native fish from impoundments to either downstream or upstream reaches may result in further adverse effects to frog populations.

Mining

Evidence of historical mining is commonly encountered within the range of the Chiricahua leopard frog, but few of these mines are currently active and most do not appear to directly affect the wetland and riparian areas occupied by the species. Only a few extant or historical Chiricahua leopard frog localities are thought to be currently directly affected by mining operations. Active mining occurs in California Gulch, Pajarito Mountains, Arizona (an historical locality), but is limited to a short reach of the drainage. Gray (2004) reports acidic drainage from the highlands of the Patagonia Mountains, Arizona, as a result of historical mining activity; but acidic runoff also occurs via leaching from naturally-occurring mineral deposits in this area, as well. Proposed mining activity by Phelps Dodge Corporation at the Santa Rita Mine could affect Chiricahua leopard frogs in the area of Hurley, New Mexico (if populations have not been eliminated by disease). Also in New Mexico, a beryllium mine is proposed on the south side of Alamosa Creek, which may affect Chiricahua leopard frog populations. The recently proposed Gentry Iron Mine may be located within 1.0 mile of two extant Chiricahua leopard frog populations on the Tonto National Forest, Arizona. The resulting effects of the proposed mining activities on these populations are uncertain at this time, but may include changes in water quality and flow rates.

In the past, spillage from mine leach ponds probably affected some Chiricahua leopard frog populations. In June 1969, leach ponds at the Phelps Dodge mine at Clifton, Arizona, breached and spilled a heavy, red residue (probably iron oxide) into Chase Creek, which flowed for four miles to the San Francisco River. Rathbun (1969) estimated a nearly 100 percent kill of "leopard" frogs and tadpoles along the four-mile reach of Chase Creek. Given the location and elevation of the site, the leopard frogs affected could have been lowland leopard frogs (*Rana yavapaiensis*) or Chiricahua leopard frogs. Overflow, leakage, and tailings dam failures at the copper mine at Cananea, Sonora, occurred several times during 1977-1979 and severely affected many miles of the upper San Pedro River, Sonora and Arizona. A spill in 1979 resulted in water that was brick red in color with a pH as low as 3.1. Aquatic life in the river was killed (U.S. Bureau of Land Management 1998). The last known occurrence of the Chiricahua leopard frog in the upper San Pedro River was 1979 (USFWS files).

Although mining activities were more widespread historically and may have constituted a greater threat in the past, the mining of sand and gravel, iron, gold, copper, beryllium, or other materials remains a potential threat to the Chiricahua leopard frog. In addition as noted above under "*Disease*", mining also has indirect adverse effects to this species.

Agriculture

Intensification of agriculture has modified the landscape and adversely affected, and in some cases benefited, wildlife in some areas. Chiricahua leopard frogs have rarely been found in association with agricultural developments (e.g. Cuchillo Negro Spring, New Mexico, Sulphur Springs Valley, Arizona); however, this form of development has likely affected the distribution of the species in some areas. Features of agricultural systems may, in some cases, be suitable as habitat for Chiricahua leopard frogs. Channels, ditches, sump ponds, farm ponds, livestock drinkers, well storage, and yard ponds might all be suitable for the Chiricahua leopard frogs in an agricultural setting, although several problems need to be considered:

- Tailwaters and return flow ditches may provide habitat; however they would need to conform to the level of permanency described under "Habitat Characteristics" to contribute to recovery.
- Agricultural regions often host harmful non-native species, often including those that disperse readily, like the American bullfrog. If these cannot be excluded, establishment of leopard frogs will be most difficult with existing knowledge and techniques.
- Agricultural areas may contain harmful chemicals, although it is not known if the levels present in specific areas would do serious harm to Chiricahua leopard frogs.

Altered Fire Regimes

Fire frequency and intensity in southwestern forests have been altered from historical conditions (Dahms and Geils 1997). Before 1900, surface fires generally occurred at least once per decade in montane forests with a pine component. Beginning about 1870-1900, these frequent ground fires ceased to occur due to intensive livestock grazing that removed fine fuels coupled with effective fire suppression in the mid to late 20th century that prevented frequent, widespread ground fires (Swetnam and Baisan 1996). Absence of ground fires allowed a buildup of woody

fuels that precipitated infrequent but intense crown fires (Swetnam and Baisan 1996, Danzer *et al.* 1997). Absence of vegetation and forest litter following intense crown fires exposed soils to surface erosion during storms, often causing high peak flows, sedimentation, and erosion in downstream drainages (DeBano and Neary 1996). Following the 1994 Rattlesnake fire in the Chiricahua Mountains, Arizona, a debris flow filled in Rucker Lake and many pools in Rucker Canyon, both of which are historical Chiricahua leopard frog localities. Leopard frogs (either Chiricahua or Ramsey Canyon leopard frogs) apparently disappeared from Miller Canyon in the Huachuca Mountains, Arizona, following a 1977 crown fire in the upper canyon and subsequent erosion and scouring of the canyon during storm events (67 FR 40790). Leopard frogs were historically known from many localities in the Huachuca Mountains; however, natural pools and ponds are largely absent now and the only breeding leopard frog populations occur in man-made tanks and ponds. Bowers and McLaughlin (1994) list six riparian plant species they believed might have been eliminated from the Huachuca Mountains as a result of floods and debris flow following destructive fires, which provides further evidence of the currently degraded conditions in montane canyons of the Huachucas.

Other Factors

Other activities have also affected the habitat of the Chiricahua leopard frog. For instance, in an attempt to increase flow, explosives were used at Birch Springs in the Animas Mountains, Hidalgo County, New Mexico, to open up the spring. The explosion resulted in destruction of the aquatic community, flows were reduced rather than increased, and Chiricahua leopard frogs subsequently disappeared (67 FR 40790). In the first half of 2001, Cuchillo Negro Spring in Sierra County, New Mexico, was excavated probably in an attempt to increase flows for downstream agricultural use. The spring, located on BLM lands, was occupied by Chiricahua leopard frogs prior to the excavation. Surveys in July 2001, after the excavation, failed to locate any Chiricahua leopard frogs, and pools that provided frog habitat had been largely destroyed; however, frogs apparently survived the event and the population is still extant (personal observations by C. Painter, Technical Subgroup, 2004).

There is renewed interest in controlling non-native saltcedar (*Tamarix* sp., but particularly *T. chinensis*), and in some cases, replacing it with native riparian trees. Purposes of control are often water salvage or restoration of native habitats. Saltcedar is well adapted for invasion of the degraded riparian systems with altered hydrology, and occurs in monoculture or near monoculture stands along many of the rivers and streams of the Southwest, particularly at elevations of less than about 4,000 feet. Although Chiricahua leopard frogs rarely occur where saltcedar is abundant, there may be some potential for these control efforts to adversely affect the frog. Herbicides used to control saltcedar, such as Arsenal, may affect the frog directly (see discussion of effects of pesticides, below); or indirectly through reduced vegetation cover, at least temporarily. Mechanical control could result in dramatic effects to cover, banklines, and water quality. Biocontrol, which is currently being tested for saltcedar control, is not likely to affect the frog, except through temporary reduced cover. Removing saltcedar, and potentially replacing it with native species, is likely to have few benefits for leopard frogs, but may have application at some sites (see Kennedy *et al.* 2005, Relict Leopard Frog Conservation Team 2005). Riparian restoration projects that do not address the underlying causes of riparian degradation, such as hydrological alteration, often fail, and may do more harm than good at great expense (Briggs 1996).

Disruption of Metapopulation Dynamics (Listing Factor A, C, D, E)

The viability of metapopulations is probably very different than small, isolated populations. In the absence of infectious disease, metapopulations are more likely to persist over time than small, more isolated populations, because individuals and genetic material can be exchanged among populations within the metapopulation, resulting in increased recolonization rates and fewer potential genetic problems. If infectious disease such as chytridiomycosis is introduced, metapopulation structure and exchange of individuals among populations would facilitate disease transmission, possibly resulting in regional die-offs or extirpation as was observed in stock tank populations in Grant County, New Mexico (Scott 1993).

Factors that alter the suitability of dispersal habitat will affect the functioning of metapopulations, as well. For instance, drought may eliminate ephemeral pools and streams upon which frogs rely during their dispersal through otherwise arid landscapes. However, wet periods may facilitate dispersal and connections among local populations. Alterations of the habitat, such as highways and urban or agricultural development reduce the ability of frogs to travel among local populations, and thus are capable of disrupting metapopulation dynamics.

Increased Chance of Extirpation or Extinction Resulting from Small Numbers or Size of Populations and the Dynamic Nature of Frog Habitats (Listing Factor A, E)

Southwestern riparian and aquatic systems are inherently dynamic due to seasonal and longer-term drought and wet periods, floods, and fire. Dynamic habitats combined with often small populations of adult frogs create circumstances in which population sizes vary greatly over time and populations are periodically extirpated. Approximately 38 percent of localities occupied by Chiricahua leopard frogs from 1994-2001 consisted of artificial tanks or impoundments constructed for watering livestock. These environments are very dynamic due to flooding, drought, and human activities such as maintenance of stock tanks. In addition, stock tank populations are often quite small. Small populations are subject to extirpation from random variations in such factors as the demographics of age structure or sex ratio, and from disease and other natural events (Wilcox and Murphy 1985). Inbreeding depression and loss of genetic diversity may also occur in small populations of less than a few hundred individuals; such loss may reduce the fitness of individuals and the ability of the population to adapt to change (Frankel and Soule 1981), as well as increase their vulnerability to environmental stressors (Weyrauch and Grubb 2006). Both of these genetic considerations result in an increased likelihood of extirpation (Lande and Barrowclough 1987).

The dynamic nature of stock tank habitats and the small size of the populations that inhabit them suggest that many of these populations are not likely to persist for long periods. As an example, siltation and drought dramatically reduced the extent of surface water at Rosewood Tank on the

Figure 5: Chiricahua leopard frog from Sycamore Canyon, Coronado National Forest, Arizona. This site is at the center of an important metapopulation. Photo by J. Rorabaugh.

Magoffin Ranch in the San Bernardino Valley, Arizona. Surface water and habitat for frogs were reduced in June 1994 to 60 square feet that supported a population of approximately eight adult Chiricahua leopard frogs and several hundred tadpoles. In this instance the landowner was only able to prevent the population from being extirpated by repeated efforts to intervene on behalf of the Chiricahua leopard frog in trucking water to the site, rebuilding the tank, and constructing a small permanent pond to maintain habitat for the species. During a drought in 2002, the number of extant populations in the Bucksin Hills area of the Coconino National Forest, Arizona, fell from nine to three. All populations were in stock tanks, and one population (Walt's Tank) was saved by rescuing frogs from the drying tank, restoration of the tank, and subsequent repatriation of the salvaged frogs in 2003. Drought also eliminated the remaining three populations (all stock tank populations) in the Baboquivari Mountains, Arizona, and may have contributed to the rapid decline in the Dragoon Mountains metapopulation. Rosen *et al.* (1996a) hypothesized that "the ongoing restriction of Chiricahua leopard frogs to shallow, marginal habitat types means that eventually the species will be wiped out by a drought (see Corn and Fogelman 1984, Fellers and Drost 1993) that it would readily have weathered in

refugia now pre-empted by non-native species. Our hypothesis clearly predicts that this species will go extinct in southern Arizona, and probably elsewhere, unless appropriate action is taken."

Some larger populations occurring in stream courses or other non-stock tank habitats also experience dramatic changes in population size, such as in Sycamore Canyon in the Pajarito Mountains, Arizona, and on the eastern slope of the Santa Rita Mountains, Arizona (67 FR 40790). These aquatic systems, although much larger than a stock tank, experience dramatic environmental phenomena such as floods, drought, and in the case of Sycamore Canyon, varied zinc to cadmium ratios and chytridiomycosis, all of which may cause populations to decline rapidly. This suggests that even these relatively large and natural habitats and the frog populations they support are very dynamic. As a result of this dynamic nature, leopard frog populations are susceptible to extirpation.

Global Climate Change, Pesticides and Other Non-Mining-related Contaminants, UV-B Radiation, and Other Stressors (Listing Factor A, D, E)

Predation by non-native species, chytridiomycosis, habitat loss and degradation, and other factors discussed have been documented as the most likely causes of population decline and extirpation of the Chiricahua leopard frog. However, populations sometimes disappear from habitats in which no changes or deterioration of habitat are apparent, no non-native predators have been detected, and for which there is no evidence of disease. In these and potentially other cases, important stressors other than those just discussed may be adversely affecting Chiricahua leopard frog populations. These factors may include climate change or climatic extremes (Dimmitt 1979, Fellers and Drost 1993, Pounds *et al.* 1999, Alexander and Eischeid 2001); transport (sometimes over long distances) and deposition of contaminants, dust, gases (Stallard 2001), and pesticides (Lips 1998, Cowman *et al.* 2001, Davidson *et al.* 2002); increased levels of ultraviolet-B radiation and interactions with pathogens, particularly a water mold (*Saprolegnia ferax*) (Blaustein *et al.* 1994, Keisecker and Blaustein 1995); acid rain (Blanchard and Stromberg 1987, Vatnick *et al.* 1999); and over-collection (Jennings and Hayes 1985).

Globally, the 22 hottest years on record have occurred since 1980, the 10 hottest years have all occurred since 1990, and 2005 was the hottest year in recorded history. The Intergovernmental Panel on Climate Change (2001) found that most of the observed warming over the last 50 years is likely attributable to greenhouse gases produced by human activities. Climate change is an ongoing process in the Southwest with associated effects to Chiricahua leopard frogs. Mean annual temperatures rose 2.0-3.1^{0}F in the American Southwest in the 20th century, and are predicted to rise 8.1-11.0 ^{0}F in the 21st century (Southwest Regional Assessment Group 2000). Predictions of changes in precipitation are less certain; however, some models predict as much as a doubling of annual precipitation, with the largest increases in winter precipitation (Southwest Regional Assessment Group 2000). But these predictions contrast with current trends of a warming North Atlantic and cooling tropical Pacific, with associated changes from a relatively wet period to drought, insect outbreaks in southwestern forests, and increasing wildfires (Patterson 1997, Betancourt 2004). Some models predict dramatic changes in southwestern vegetation communities as a result of climate change (Thompson *et al.* 1997). Arizona's forested areas could decline by 15-30 percent as a result of hotter and drier conditions that fuel wildfires, as well as warmer winters that promote forest insect outbreaks. Arizona's two largest

wildfires on record occurred in 2002 and 2005 (Arizona Climate Change Advisory Group 2006). Climate change can occur abruptly, with associated major changes in the environment (National Academy of Science, Committee on Abrupt Climate Change 2002).

The potential for climate change and the uncertainty as to how it may manifest, particularly in regard to precipitation patterns, add considerable uncertainty to predicting the future status and threats to the Chiricahua leopard frog, as well as the strategies needed to recover the species. For instance, drought driven by climate change could result in extirpations of Chiricahua leopard frogs from stock tanks and other marginal habitats subject to drying. If rainfall increases, potential habitat for Chiricahua leopard frogs may increase, as well. Yet, increased precipitation may provide more opportunities for predators to spread and adversely affect remaining frog populations, offsetting any benefits due to more mesic conditions for Chiricahua leopard frogs. Drought would likely reduce habitat for and invasion by non-native predators. Increasing temperatures have the potential to alter frog breeding phenology, with unknown effects to frog populations and predators of Chiricahua leopard frogs (Blaustein *et al.* 2001, Beebee 2002). During drought, proximity of suitable drought-resistant habitats may be critical to persistence of each frog population. If Chiricahua leopard frogs cannot disperse from drying habitats and reach suitable habitat, droughts are likely to produce major, though not necessarily irreversible, population declines. Small drought refugia, such as crevices in concrete near an overflowing drinker, or an accessible water storage tank or drinker that the frogs can get into and out of can become critically important for survival of frogs.

Potential direct effects of increased temperatures on the species include earlier reproduction in spring, more rapid development, shorter period of hibernation, longer period of aestivation, changes in abilities to find food, spread of infectious disease, and changes in immune function (Blaustein *et al.* 2001, Beebee 2002). Increasing temperatures may affect the population dynamics of chytridiomycosis, because the fungi's growth (Collins *et al.* 2003, Piotrowski *et al*. 2004) and effectiveness of antimicrobial peptides on the skin of ranid frogs (Longcore *et al.* 1999) are temperature dependent. If increased temperatures are coupled with reduced precipitation, a variety of indirect effects could occur as well, including habitat loss and fragmentation, and changes in interactions with prey, competitors, predators and parasites, which may form the most serious adverse consequences of climate warming on amphibian populations.

Atmospheric ozone depletion over the last 40 years has resulted in increased ultra-violet (UV)-B radiation reaching the earth's surface. Potential direct effects of increased solar UV radiation on amphibians consist of abnormal embryonic and larval development, damage to the eye and skin, and systematic effects through the suppression of the immune system. Indirect effects include changes in the relative abundance and species composition of competitors, predators and/or parasites, as well as toxic effects of chemicals produced or released as a result of photochemical reactions. Nocturnal and secretive habits of many amphibians protect them from exposure to solar UV. Pigmentation and an ability to repair UV-induced damage are likely to determine the sensitivity of those species that are regularly exposed to solar radiation at different phases of their life cycle (Ovaska 1997).

Aquatic habitats are often the ultimate sinks for herbicides, insecticides, fertilizers, sewage, and other contaminants. These chemicals have a variety of direct and indirect effects on amphibians and other components of aquatic communities (Sparling 2003, Reylea 2005). Airborne movement and deposition of acidic compounds, pesticides, and potentially other chemicals over long distances can affect otherwise pristine areas that do not receive direct applications (Blanchard and Stromberg 1987, Davidson *et al.* 2002), and some pesticides may cause sublethal effects at very low dosages (Hayes *et al.* 2002, 2004, 2006; but see Carr *et al.* 2003).

No studies have been conducted evaluating effects of pesticides on the Chiricahua leopard frog. Many studies are available for other amphibians (see Sparling [2003] for a recent review of the role of contaminants in amphibian decline); however, these studies often examine acute toxicity in the laboratory, rather than the entire range of effects, including sublethal responses and interactions or additive effects with other environmental stressors in the field that can alter population dynamics. There are no Federal regulatory criteria on toxicants for amphibians. Rather, fish tolerance levels are often assumed to be representative for amphibians. However, Birge *et al.* (2000) demonstrated that amphibians typically had lower LC_{50} (the concentration that kills 50 percent of the test organism in a given time) than fish and had greater variation among species in their sensitivity to metal and organic compounds, therefore suggesting that water quality criteria established for fish may not be adequate to protect amphibians (also see Paulk and Wagner 2004).

Recent studies indicate that some pesticides and industrial chemicals at concentrations found in the environment can cause endocrine disruption, feminization of male frogs, and potentially population declines. Through analysis of museum specimens, Reeder *et al.* (2005) demonstrated that intersexuality or hermaphrodism in Illinois cricket frogs (*Acris crepitans*) was correlated with periods of greatest use of DDT and PCBs, and in the most industrialized and urbanized portions of Illinois. They surmised that intersexuality caused declines in cricket frog populations. The herbicide Atrazine disrupts endocrine function and even at very low concentrations of $\geq$ 0.1 ppb caused retarded gonadal development, hermaphroditism, and oocyte growth in male northern leopard frogs. Atrazine contamination is widespread in the U.S. and can be present in excess of 1 ppb even in precipitation and areas where it is not used (Hayes *et al.*, 2002). Mixtures of pesticides often found together in the environment can cause much greater effects than are revealed by laboratory studies investigating effects of individual pesticides. In northern leopard frogs, pesticide mixtures resulted in smaller sizes at metamorphosis, and immunosuppression and contraction of flavobacterial meningitis, which may have been caused by increased plasma levels of the stress hormone corticosterone (Hayes *et al.* 2006).

Effects of chemicals, UV radiation, disease, parasitic infestations, temperature, pH, or other environmental factors may, in some cases, interact or be synergistic (see Carey *et al.* 2001). Effects of chytridiomycosis may be greater when frogs are exposed to heavy metals or other environmental factors (Rollins-Smith *et al.* 2002, Parris and Baud 2004). There is growing evidence that the deleterious effects of UV radiation and chemicals may interact or be additive. For instance, in the laboratory, northern leopard frog tadpoles exposed to the pesticide s-methoprene exhibited a deformity rate of 2.1 percent, whereas those exposed to both UV and s-methoprene had a deformity rate of 8.7 percent (Akins and Wofford 1999). Exposure of northern leopard frog tadpoles to UV-A, simulating a fraction of summertime, midday sunlight

in the northern latitudes, significantly increased the toxicity of fluoranthene (Monson *et al.* 1999). UV-B radiation and octylphenol, an estrogen-disrupting chemical, together altered larval development and hypothalamic gene expression in northern leopard frogs, but neither caused these effects when acting alone (Crump *et al.* 2002). In the Pacific Northwest, *Saprolegnia ferax*, an oomycete pathogen of amphibian embryos, may act alone to cause mortality, but it also acts in synergy with UV-B radiation in a way that increases mortality (Keisecker and Blaustein 1995). *Saprolegnia* is also a common disease in fish hatcheries and may be spread with stockings of hatchery-raised rainbow trout or other fishes (Kiesecker *et al.* 2001). Levels of UV-B radiation and mildly acidic waters that alone showed no detectable effect on survival of northern leopard frog embryos, caused significant declines in survival when acting in concert (Long *et al.* 1995). Reylea *et al.* (2005) demonstrated that pesticides, although often having direct effects on tadpole survival, can also result in increased survivorship indirectly via mortality of tadpole predators. Predatory stress can dramatically increase the susceptibity of anurans to the insecticides carbaryl (Reylea 2003) and malathion (Reylea 2004). High pH (7.5) increased the toxic effects of the herbicide Vision on northern leopard frogs (Chen *et al.* 2004). Although such synergistic, additive, or indirect effects have not been studied in the Chiricahua leopard frog, we cannot rule out that they have played a role in the population dynamics of this species, or may do so in the future.

Below we present additional information about specific contaminants:

Organic Industrial Chemicals
Polychlorinated Biphenyls – PCBs were produced as coolant and dielectric fluids for use in electrical capacitors from the 1930s to the 1970s. There were also used in paints, carbon paper, mimeograph ink, and a range of other products. Although they are no longer being produced, their persistence in the environment and volatility are reason for concern. Their effects on wildlife are typically associated with chronic toxicity, attributable to their tendency to bioaccumulate. Benzene, Phenol, and crankcase oil are also organic industrial chemicals that have caused mortality in amphibians.

Agricultural Chemicals
The possible contribution of the nitrate enrichment of water bodies to amphibian population declines in the intensively agricultural areas of the U.S. has become a topic of considerable concern. Amphibians in this region often live in proximity to and/or in waters draining agricultural lands. Clinical signs include weight loss, reduced activity, poor response to prodding, and developmental abnormalities. Agricultural contaminants are the suspected cause of deformities observed in northern leopard frogs on the St. Lawrence River Valley, Quebec, although variation in the proportion of deformities among sites was too large to conclude there was a difference between control and pesticide-exposed habitats. Conspicuous deformities interfered with swimming and hopping and likely constituted a survival handicap (Ouellet *et al.* 1997).

Pesticides
Application of pesticides in forestry and agriculture results in unavoidable contamination of adjacent water bodies. Amphibian communities of small ponds in the application areas are particularly vulnerable. Sublethal effects of pesticides on amphibians may influence the survival

and success of exposed aquatic stages. If they are not directly lethal, the exposures may result in increased predation, reduced feeding, and delayed growth. Tadpoles may fail to reach metamorphosis at an appropriate time or size (Berrill *et al.* 1997). Pesticides may contribute to observed limb malformations in northern leopard frogs and other anurans (Fort *et al.* 1999a and b). In the laboratory, a variety of pesticides caused immunosuppression in northern leopard frogs and altered their ability to deal with parasitic infection (Gilbertson *et al.* 2003, Christin *et al.* 2003). As discussed above, interaction among effects of herbicides and other stressors, such as low pH, predation, and UV-B can interact to exacerbate effects on larval amphibians.

Herbicides
Triazine herbicides, Trichlopyr, Phenoxy herbicides, Dipyridyl herbicides, and glyphosates have been shown to cause mortality in amphibians.

Insecticides
Many insecticides formerly applied directly to water are no longer available for use in the United States. However, runoff from treated fields, lawns and other areas still may be a problem. Pyrethroids, Cholinesterase-Inhibiting insecticides, Carbamate insecticides, Organophosphorus insecticides, and Organochlorine insecticides, have been shown to cause mortality in amphibians.

Piscicides
Rotenone is a plant-derived piscicidal and insecticidal compound commonly used in the eradication of undesired fish stock. Tissues of rotenone-poisoned animals are unable to use oxygen in cellular respiration, inducing signs of oxygen deficit, even when air or water oxygen concentrations are adequate. Treatment of waters for fish eradication or research, therefore, likely kills larval amphibians as well.

Metals
Mercury, cadmium, lead, and aluminum are well-known environmental contaminants. Acidification of the environment (from hydrogen ions) occurs largely from atmospheric fallout of the products of fossil fuel combustion. Among the more important effects of this acidification of the aquatic environment on amphibians is reduced hatching of eggs and reduced rates of growth.

Fire retardants and suppressants
Each year, millions of gallons of fire retardants and suppressants are broadly applied aerially and from the ground to wildlands in the Western U.S. Contamination of aquatic sites can occur via direct application or runoff from treated uplands. These chemicals are ammonia-based, which in itself can be potentially toxic; however, many formulations also contain yellow prussiate of soda (sodium ferrocyanide), which is added as an anticorrosive agent. Such formulations are toxic to a variety of aquatic and other organisms, including leopard frogs. Toxicity of these formulations is typically found to be low in the laboratory, but in the field toxicity to the southern leopard frog (*Rana sphenocephala*) and rainbow trout has been found to be photoenhanced by ambient UV radiation (Calfee and Little 2003).

Administrative, Political, and Cultural Barriers to Recovery (Listing Factor E)

The threats for this species are immediate, and therefore require immediate interagency administrative solutions and management actions to ensure recovery. Implementation of population establishment efforts may occur over a timescale that is subject to shifts in administrative influences. Differing goals and mandates of various agencies also may result in challenges to conservation of this species. Considerations that influence agency actions may include the perception of the ease of recovery, private property rights, and issues of jurisdiction. In addition, funding availability has been declining as an increasing number of species are competing for decreasing funds.

Frogs are increasingly visible in popular culture, but typically there is little understanding of the value of species in one's backyard and little value attached to the presence of native frogs in landscapes. In addition, some cultures have taboos or beliefs regarding frogs that may create barriers to recovery actions involving surveys, handling, or reestablishment of frogs. Cultural barriers to recovery can, in some cases, be overcome through outreach and education. The informed public will often support recovery efforts, or at least will be able to evaluate potential costs and benefits and formulate an informed opinion.

Previous and Ongoing Conservation Measures

The Chiricahua leopard frog occurs on Federal lands managed by the Coronado, Apache-Sitgreaves, Tonto, Coconino, and Gila National Forests; the BLM; and USFWS refuges. Examples of Federal actions that may affect the Chiricahua leopard frog include dredge-and-fill activities, grazing programs, construction and maintenance of stock tanks, logging and other vegetation removal activities, management of recreation, road construction, fish stocking, issuance of rights-of-way, prescribed fire and fire suppression, and discretionary actions authorizing mining. These and other Federal actions require consultation under section 7 of the ESA if the action agency determines that the proposed action may affect listed species. The outcome of the section 7 consultation often involves inclusion of reasonable and prudent measures into project plans to minimize take of listed species or otherwise reduce potential adverse effects to the species and its habitat. In biological opinions, USFWS also provides conservation measures that Federal agencies can implement on a voluntary basis. Since the Chiricahua leopard frog was listed, USFWS has consulted with several National Forests in Arizona and New Mexico on proposed operation of grazing leases, and in cooperation with the Forests, USFWS has drafted criteria for guiding determinations of effect in regard to section 7 grazing consultations on the frog. Development on private or State lands requiring permits from Federal agencies, such as permits from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act, are also subject to the section 7 consultation process. Federal actions not affecting the species, as well as actions that are not federally funded or permitted, do not require section 7 consultation. However, prohibitions under section 9 of the ESA (discussed below) apply.

The ESA and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered and threatened wildlife. These prohibitions, codified at 50 CFR 17.31, in part, make it illegal for any person subject to the jurisdiction of the United

States to take (including harass, harm, pursue, hunt, shoot, wound, kill, trap, or collect, or attempt any such conduct), import or export, transport in interstate or foreign commerce in the course of a commercial activity, or sell or offer for sale in interstate or foreign commerce any threatened species unless provided for under a special rule. It is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions will apply to persons acting in an agency capacity on the behalf of USFWS and to activities associated with cooperative State conservation agencies.

Permits may be issued to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances. Regulations governing permits are codified at 50 CFR 17.32. Such permits are available for scientific purposes, to enhance the propagation or survival of the species, and/or for incidental take in connection with otherwise lawful activities. For threatened species, permits also are available for zoological exhibition, educational purposes, or special purposes consistent with the purposes of the ESA.

When the Chiricahua leopard frog was listed in 2002, the USFWS also finalized a special rule promulgated under Section 4(d) of the ESA. The rule states that incidental take of the species will not be considered a violation of section 9 of the ESA if that take results from livestock use or maintenance activities at livestock tanks located on private, State, or Tribal lands. "Livestock tanks" were defined as an existing or future impoundment in an ephemeral drainage or upland site constructed primarily as a watering site for livestock. The purpose of the special rule was to not penalize ranchers on non-Federal lands who through development and maintenance of livestock tanks have created habitat for Chiricahua leopard frogs, but through their ranching activities may incidentally take frogs. Incidental take resulting from ranching activities on Federal lands is appropriately addressed under Section 7 consultations, and incidental take can and has been anticipated and authorized through biological opinions issued by the USFWS to Federal land managers that authorize grazing activities.

Important regional efforts are currently underway to establish viable metapopulations of Chiricahua leopard frogs. USFWS, AGFD, NMDGF, University of Arizona, Western New Mexico University, the Ladder Ranch, The Nature Conservancy, several Federal agencies, and the Malpai Borderlands Group are working together in these efforts. An ongoing regional conservation planning effort in the San Bernardino Valley, Arizona being undertaken by the USFWS, the Forest Service, State, and private individuals is a good example of such efforts. Owners of the Magoffin Ranch, in particular, have devoted extensive efforts to conserving leopard frogs and habitat at stock tanks on their ranch (Rosen *et al.* 2001). As part of the San Bernardino Valley conservation effort, a high school teacher and his students reared tadpoles in Douglas, Arizona, and established populations of Chiricahua leopard frogs in small constructed wetlands at Douglas area public schools (Biology 150 Class, Douglas High School 1998). A Safe Harbor Agreement was signed in 2004 with the Malpai Borderlands Group, which includes cooperating ranches in the San Bernardino Valley and adjacent Peloncillo and Animas mountains, and the Animas and Playas valleys, New Mexico. The Safe Harbor Agreement is expected to promote conservation of Chiricahua leopard frogs in this region. Landowners in the Altar Valley of southern Arizona are also interested in developing a Safe Harbor Agreement with the USFWS. AGFD and USFWS have recently completed a State-wide Safe Harbor Agreement through which individual landowners anywhere in Arizona can be covered by a master recovery

permit held by AGFD. In another regional conservation effort, the Tonto National Forest, Arizona, AGFD, and the Phoenix Zoo have developed a Chiricahua leopard frog "conservation and management zone" in which frogs have been reared and released into the wild to establish new populations (Sredl and Healy 1999). In the White Mountains of Arizona, Chiricahua leopard frogs originating from Three Forks and reared at the AGFD's Pinetop Office were released at Sierra Blanca Lake in May 2004. Another effort to remove non-native predators for future repatriation of Chiricahua leopard frogs was undertaken at Buenos Aires National Wildlife Refuge, Arizona (Schwalbe and Rosen 2001). A refugium population of Chiricahua leopard frogs was established at a ranch in the Altar Valley in July 2004, as a source of animals for possible future repatriation projects in that area. On the Ladder Ranch in New Mexico, efforts are underway to monitor populations, test for diseases, conduct radio telemetry studies, fence livestock tanks to encourage riparian plant growth, control American bullfrogs, investigate parasites of Chiricahua leopard frogs, and translocate frogs for the purpose of establishing new populations (Christman *et al.* 2003). This project is supported by the Turner Endangered Species Fund and State Wildlife Grants Program through NMDGF. The Nature Conservancy and Randy Jennings established a new population of Chiricahua leopard frogs on the lower Mimbres River, New Mexico. These regional conservation plans are proving grounds for developing the techniques to recover the species rangewide.

The Ramsey Canyon leopard frog conservation agreement and strategy is another example of collaborative effort to recover what are considered herein to be populations of Chiricahua leopard frogs. Efforts by USFWS, AGFD, the Coronado National Forest, Fort Huachuca, The Nature Conservancy, The Phoenix Zoo, private interests (such as the Beattys, Rutherfords, Ann Craven, Sarah Barchas), and other partners have likely prevented this species from going extinct (Sredl *et al.* 2002).

Although Federal listing provided much needed protection and oversight, and the conservation actions described above are a great start on recovery, much needs to be accomplished before the Chiricahua leopard frog is no longer threatened with extinction. The species has declined and populations have been lost since the species was listed in 2002. Drought and disease, in particular, have been the proximate causes of these recent declines, but non-native predators, habitat degradation, and potentially other factors are driving forces, as well. These threats will need to be abated across the range of the species, but because populations are currently so few and isolated, translocation of frogs into currently unoccupied habitats will be key in reestablishing secure populations and metapopulations. This work will only be possible through cooperative efforts among agencies, landowners, Tribes, and other willing partners.

Biological Constraints and Needs

Amphibian populations tend to fluctuate widely because of their susceptibility to vagaries of biological constraints, especially their dependence on seasonal aquatic habitats. The stability of populations may depend in part on the species' ability to recolonize vacated sites and maintain connections among extant populations. If natural recolonization is insufficient, reintroductions may be necessary to maintain natural populations. Suitable habitat must contain certain characteristics if this species is to survive. The tadpole is fully aquatic, thus water must be available in sufficient quality and quantity long enough ($\geq$3 months) for metamorphosis. Small

patches of suitable aquatic habitat must be within the dispersal range of metamorphs. These aquatic corridors may be critical in the conservation of Chiricahua leopard frogs. Vegetation cover sufficient to provide refuge from predators and desiccation must be present for long-term survival.

Water

Moisture is the principal factor affecting the ecological distribution of amphibians (Duellman and Trueb 1986). Chiricahua leopard frogs are highly aquatic frogs that need permanent to semi-permanent water for survival. The tadpole stage is entirely aquatic. Prior to introduction of non-native predators, the adults were aquatic habitat generalists, using a large variety of natural and man-made sites including rivers, streams, beaver ponds, cienegas, springs, earthen stock tanks, livestock drinkers, irrigation sloughs, wells, abandoned swimming pools, and mine adits (Sredl and Jennings 2005). Except during overland dispersal during wet periods, these frogs rarely are found far from these water bodies. Therefore, these water bodies must be relatively free from non-native predators including crayfish, fishes, and American bullfrogs.

Highly polluted waters do not support Chiricahua leopard frogs. Frogs require reasonable water quality and quantity (see Appendix F, Table F1).

Cover

Shoreside vegetation and rooted aquatic vegetation that provide cover are important for the conservation and maintenance of Chiricahua leopard frog populations. Those populations that occur in aquatic habitats that are only seasonally inundated and have only muddy banks with no vegetative cover generally consist of metamorphs that will soon disperse from these sites. However, a few large adults may inhabit these sites if cover exists in the form of rooted aquatic vegetation, deep muddy water, root wads, undercut banks, or flood debris. The lack of cover at these sites increases the predation pressure and populations tend to be small and secretive.

Female Chiricahua leopard frogs deposit spherical egg masses that are usually attached to rooted aquatic vegetation (e.g., *Polygonum*, *Potamogeton*, *Ranunculus*, *Rorippa*, Cyperaceae, Gramíneae). However, the lack of such vegetation does not preclude egg deposition, and eggs are occasionally deposited on submerged or partially submerged debris including Russian thistle (*Salsola* sp.) and other wind blown debris. Nothing is known about the survivorship of eggs attached to rooted aquatic vegetation versus debris.

Chiricahua leopard frogs are expected to be invertebrate generalists, consuming a wide variety of flying and terrestrial insects and other arthropods (Degenhardt *et al*. 1996). Sites that lack some vegetation cover tend to have a relative depauperate invertebrate fauna and thus less potential prey for leopard frogs.

PART II. RECOVERY

Recovery Goal

The goal of the recovery plan is recovery and delisting of the Chiricahua leopard frog.

Recovery Strategy

To meet the recovery goal of delisting, the frog must reach a population level and have sufficient habitat distributed throughout its historical range to provide for the long-term persistence of metapopulations in each of eight recovery units (RUs), even in the face of local losses (e.g., extirpation). Threats that led to the listing of the frog must be reduced or eliminated to maintain or increase population levels and protect habitat. The recovery strategy has six key elements designed to conserve the frog in each RU and throughout its historical range:

1. protect and manage remaining populations and habitats;
2. restore and create habitat, and establish additional populations as needed to build viable metapopulations and isolated robust populations in each RU;
3. monitor progress towards recovery;
4. research the conservation biology of the frog with the objective of facilitating efficient recovery;
5. develop support and build partnerships to facilitate recovery; and
6. practice adaptive management in which the recovery plan and management actions are revised to reflect new information developed through research and monitoring.

Recovery of the Chiricahua leopard frog will use a geographic approach; that is, tailoring recovery actions to the varying ecological and socio-political circumstances that occur across the species' range. This approach forms the foundation of the recovery strategy and the recovery criteria, described in the following section. Eight recovery units (RUs) are delineated (Figure 6), corresponding to these varying circumstances. RUs are geographic or otherwise identifiable subunits of the listed entity that individually are necessary to conserve genetic or demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the entire listed entity. For the Chiricahua leopard frog to be recovered, conservation of the frog must occur in each RU. Conserving the frog within each RU ensures that when recovered, it will be well-distributed and threats will be lessened or alleviated throughout its historical range. If it is conserved and well-distributed within its historical range, then it will no longer be threatened throughout a significant portion of its range and will warrant delisting. The RUs cover the entire known range of the species; however, as discussed in Part 1 of this plan, there is uncertainty as to the species' distribution south of central Chihuahua. Figure 6 shows localities for the Chiricahua leopard frog in southern Chihuahua from Platz and Mecham (1979) that have been questioned by other authors (Webb and Baker 1984).

This strategy and the implementation of recovery actions address the needs of each RU and focus on management areas (MAs), which are areas within RUs with the greatest potential for successful recovery actions and threat alleviation. MAs contain extant populations or sites where habitats will be restored or created, and populations of frogs established or re-established.

Existing populations and suitable habitat in MAs will be protected through management defined in conservation easements or agreements with Tribes, Mexican partners, willing landowners on non-Federal lands, and through section 7 consultations and agreements with land management agencies on Federal lands. Management will include maintaining or improving watershed conditions both upstream and downstream of frog habitats to reduce physical threats to aquatic sites and allow for frog dispersal, reducing or eliminating non-native species, preventing and managing disease, and other actions. We recognize that within RUs, opportunities will vary for recovering the frog; thus at least two and up to seven MAs are identified in each RU. However, successful conservation is not necessary in every MA and recovery does not depend upon an even distribution of recovery efforts across an RU. Rather, we anticipate that recovery efforts will be focused in those MAs and portions of RUs in which opportunities are best. We recognize that some jurisdictions and landowners within the RUs may not wish to participate in the recovery effort.

Suitable or potentially suitable unoccupied habitat with high potential for supporting frog populations or metapopulations (referred to here as recovery sites) will be protected, and restored or created as needed, within MAs. These habitats will include aquatic breeding habitats and uplands or ephemeral aquatic sites needed for movement among local populations in a metapopulation. Activities to achieve this include habitat management, removal of non-native species (e.g. American bullfrogs, non-native fishes, and crayfish), enhancing water quality conditions, and reducing sedimentation. Populations of Chiricahua leopard frogs will be established or reestablished in these recovery sites. Establishment of populations will occur by natural colonization from adjacent sites, captive propagation, headstarting, and/or translocation. These recovery sites should, through building of metapopulations and creation of robust populations (see Appendix K for definitions), promote long-term viability or persistence of the Chiricahua leopard frog in each RU. Establishment and maintenance of metapopulations and isolated, robust populations are important to long-term persistence. Compared to individual populations, metapopulations are more likely to persist in the long-term, at least in the absence of disease. However, isolated but robust populations will provide buffers against disease that could decimate a metapopulation. Establishing at least two metapopulations in each RU will further increase the likelihood of long-term persistence, particularly if metapopulations occur in different drainages, so that a single environmental catastrophe such as a fire or flood will not result in the extirpation of all of the frogs. Based on population viability modeling (Appendix C), evidence of long-term persistence for metapopulations and isolated but robust populations can consist of monitoring that documents persistence for at least 25 years, or other such evidence, such as persistence for at least 15 years coupled with commitments for long-term management (e.g. agreements with landowners and water rights holders, abatement of threats and no reason to believe those threats will remanifest, etc.). Persistence is strongly influenced by climatic cycles. During drought, frog populations may be lost, particularly from runoff-fed livestock tanks and other sites susceptible to drying. During wet periods, frogs may colonize new habitats, including sites that normally are dry. Non-native predators may also benefit during these wet periods. Evaluations of long-term persistence need to consider these potential effects and how persistence during a 15 or 25-year period may or may not be representative or indicative of persistence in the long term.

As with existing populations, and where desirable, upland and ephemeral aquatic habitats will be protected or restored to encourage movement of frogs among sites to maintain metapopulation dynamics. The amounts and types of upland and ephemeral habitats needed to support movement among breeding sites will vary by site and will need individual evaluation. Augmentation of existing populations may occur to bolster populations after environmental disasters or to enhance genetic diversity. Refugial or actively-managed populations will be established as needed to ensure persistence of local or regional demes of frogs, and to serve as a source of frogs in case of extirpation. Immediate action is needed in some RUs (particularly RUs 4 and 7) to prevent extirpation. Pursuit of longer-term recovery objectives may have to wait in these areas until populations are stabilized.

Building grassroots public support for the recovery effort is key to overcoming administrative and political barriers to recovery. Because such barriers develop as a result of the cultural environment, the recovery effort should include actions designed to enhance public perception of the value of the Chiricahua leopard frog and associated recovery efforts. Local or regional recovery implementation should focus on broadly inclusive community-based planning. Efforts should include all viewpoints and the agency decision-makers should be regularly informed of the status of meetings to ensure that the outcomes conform to their expectations. Education and outreach will complement these efforts by again building support and understanding of the recovery program, as well as developing conservation partnerships with landowners and land managers, water rights holders and dam/reservoir operators, recreationists, ranchers, anglers, and others that use and enjoy public lands. Coordination and outreach through the Stakeholder Subgroups (see Appendix A) and other avenues will be pursued to inform the public of this recovery plan and to include public input into recovery implementation. Momentum for continued progress towards recovery will be facilitated by annual or more frequent meetings of Stakeholders and Technical subgroups of the recovery team.

Monitoring will occur to track the status of extant and established/re-established populations, to assess threats to the species and its habitat, and to evaluate the implementation and effectiveness of this recovery plan. A scientifically acceptable monitoring protocol will need to be developed that will accomplish this task. Monitoring data will be compiled into annual reports to assess recovery plan implementation and whether the recovery criteria have been met. Where appropriate, such data or summaries should be made available to the public as part of the outreach program.

Research will be conducted to promote conservation and management of the frog. Specifically, information will be developed to improve this recovery strategy and implementation of recovery actions. Two critical areas of research include the identification of the effects of transmission and treatment of chytridiomycosis and development of effective means of controlling non-native predation.

Last, as new information is developed through monitoring, research, and other sources, this recovery plan and its implementation will be revised based on new information to ensure that efficiency and effectiveness of the recovery effort are maximized.

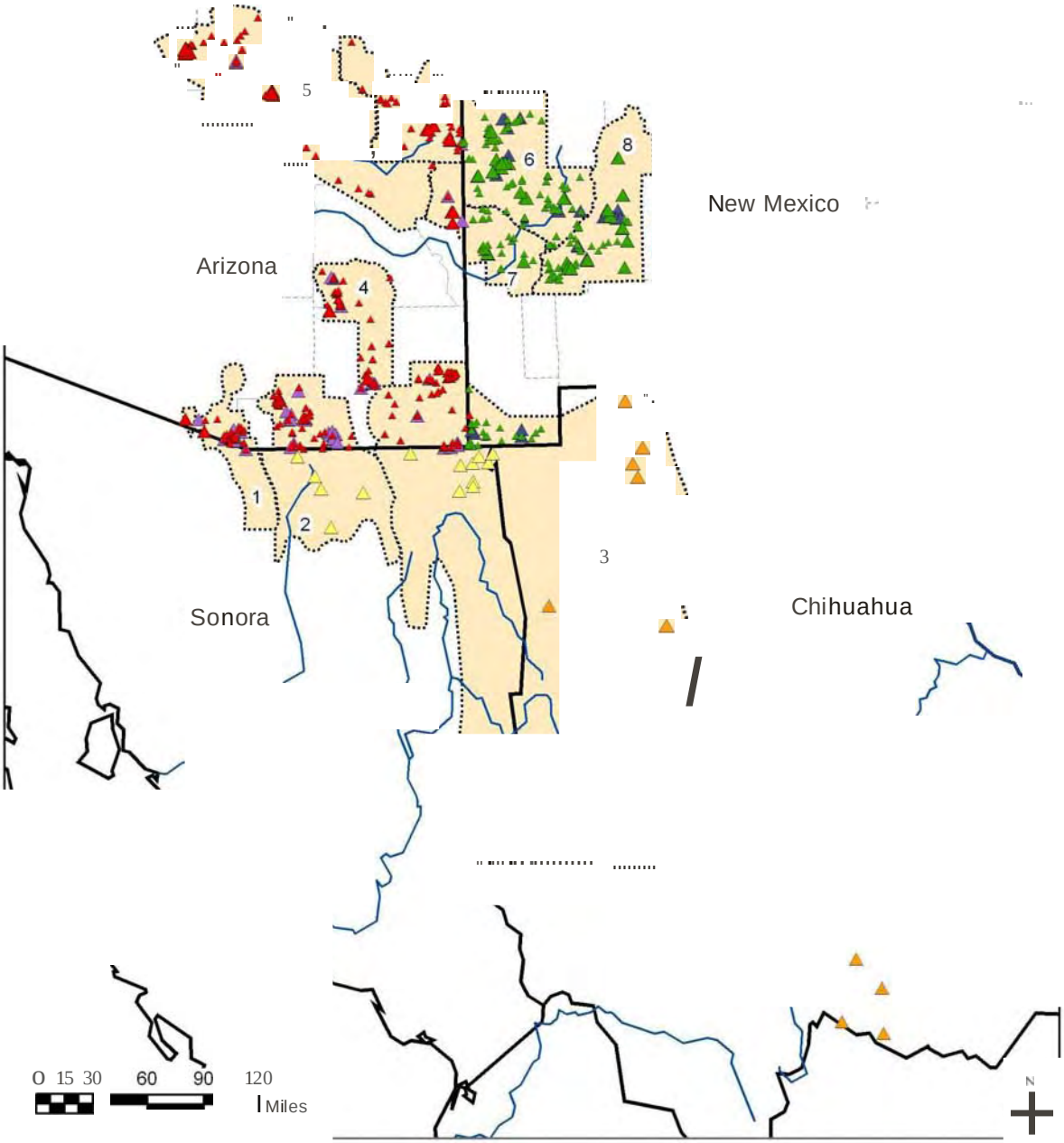

Figure 6: Recovery Units

Chiricahua Leopard Frogs in **New Mexico**
- 1917-1999
- 2000-2002

Chiricahua Leopard Frogs In **Arizona**
- 1928-1999
- 2000-2003
- Chiricahua Leop... Frogs in Chihuahua
- Chiricahua Old Frogs -- Sonora
- Frogs y Present - Arizona
- Frogs Lik resent - New Mexico
- Rivers
- Counties
- Recovery Un..
- Affected States

RECOVERY UNITS

No	Name
1	Tumacacori Highlands
2	Upper San Pedro-Santa Cruz
3	Malpais-Cajon Bonito
4	Graham-Galiuros-Willcox
5	Mogollon Rim - Verde
6	Gila - White Mountains
7	Gila - Blue
8	Mimbres - Alamosa

Recovery Criteria

The Chiricahua leopard frog will be considered for delisting when:

1. At least two metapopulations located in different drainages (defined here as USGS 10-digit Hydrologic Units) plus at least one isolated and robust population occur in each RU that exhibit long-term persistence and stability (even though local populations may go extinct in metapopulations) as demonstrated by a scientifically acceptable population monitoring program. Interpreting the results of the monitoring program will take into account precipitation cycles of drought or wet periods and the effects of such cycles on population persistence.

2. Aquatic breeding habitats, including suitable, restored, and created habitats necessary for persistence of metapopulations and robust isolated populations identified in criterion 1, are protected and managed in accordance with the recommendations in this plan.

3. The additional habitat needed for population connectivity, recolonization, and dispersal is protected and managed for Chiricahua leopard frogs, in accordance with the recommendations in this plan.

4. Threats and causes of decline have been reduced or eliminated, and commitments for long-term management are in place in each RU such that the Chiricahua leopard frog is unlikely to need protection under the ESA in the foreseeable future.

The rationale for these criteria is explained in the Recovery Strategy, above. Definitions of terms are found in the Glossary (Appendix K). Threats and causes of decline cannot be addressed in a "one size fits all manner", given the variety of circumstances across the range of the frog; therefore crucial recovery needs to lessen and alleviate the most significant threats are addressed by recovery unit in the following section. Recovery criteria are designed to provide a basis for considering a change in the status of the Chiricahua leopard frog, but would not trigger automatic delisting. Such decisions are made by the USFWS through a rule-making process that involves public review and comment. A proposal to delist must evaluate threats that comprise the same five listing factors that were discussed in the final rule listing the Chiricahua leopard frog (see a discussion of these factors in the section "Minimization of Threats to the Chiricahua Leopard Frog Through Implementation of Recovery Actions"). If, based upon the best information available, threats have been abated or are otherwise reduced to the point that the species is no longer threatened throughout a significant portion of its range, then delisting is warranted and would be proposed. The "best information available" would include interpretation of any monitoring data collected in accordance with this plan, whether the recovery criteria are met, and any other factors or data. If the proposed finding to delist the frog withstands public review and comment and no other information becomes available disputing the finding, then the species would be delisted in a final rule.

Recovery Units

The eight RUs are natural units in which frog metapopulation dynamics function or could function as the species recovers. Each unit is large enough to ensure that frog carrying capacity is buffered against changes due to potential successional processes or environmental disasters (e.g. floods, fire, drought, and climate change). The RUs cover the entire known range of the species in Arizona, New Mexico, and adjoining portions of Mexico, which ensures that when recovered, the frog will be well-represented throughout its present and historical range. However, differences in habitats, threats, land ownership and management, and political boundaries provide for different recovery challenges across the frog's range. As a result, RUs were also designed to delineate areas of similar recovery challenges. Hydrological units and the elevational limits of the species help to further define the boundaries of RUs. In addition, and as discussed in Part 1, there is evidence that the Mogollon Rim populations differ genetically from those in southeastern Arizona, southwestern New Mexico, and Mexico, and differences may occur among drainages or mountain ranges, as well (Platz and Grudzein 1999, Goldberg *et al.* 2004, Hillis and Wilcox 2005). RUs 1-4 cover the southern populations, while RUs 5-8 contain the Mogollon Rim populations. These two groups of RUs are disjunct (Figure 6). The eight RUs provide for recovery within the Mogollon Rim and southern groups of populations, but also allow for recovery within smaller geographic areas such as watersheds and mountain ranges that likely also exhibit local adaptation. Although our aim is to conserve genetic diversity within and among the RUs, it is not a criterion for recovery. If all populations are lost within an RU, frogs may be imported from an adjacent RU (see Appendix D).

The RUs are designed to promote local conservation efforts. Attempting to recover the species rangewide is a daunting task, but when approached from the perspective of RUs, recovery becomes a more manageable proposition. Several of the RUs have ongoing conservation activities for the frog that could become the nucleus of local efforts to achieve recovery. Further information on how RUs were delineated is found in the descriptions of each unit, below.

Within RUs, it will be important to implement recovery actions over large landscapes with the greatest potential for successful recovery. These areas are identified as MAs. MAs include the immediate watersheds (typically USGS 10-digit Hydrologic Units) that surround extant populations and potential recovery sites, and are further constrained by regional elevational distribution limits of the frog (see Table E1 of Appendix E). Hydrologic units and mountain ranges are used as MA boundaries because activities that may affect frog populations and their habitats, and thus may need management under this plan, are most often downstream or upstream within the same watershed as those populations. Borders for these areas have in some cases been modified to match agency or other jurisdictional boundaries to facilitate management. For instance, the MAs in northeastern Sonora follow the boundaries of the several units of the El Bosque Nacional y Refugio de Vida Silvestre Los Ajos-Bavispe (Ajos-Bavispe Forest Reserve and Wildlife Refuge). MAs are described and mapped in the narratives for each RU in Appendix B. MAs have been delineated to include all habitats of known extant frog populations as well as other sites with the highest potential for recovery, including sites where habitat restoration or creation, and establishment or re-establishment of frog populations will likely occur or has already occurred. We include all known extant populations within MA boundaries because of

the high value of those populations for recovery. Because so few populations of Chiricahua leopard frogs are extant, and we do not yet know the extent of genetic variability across the range of the species, each population may be critical to recovering and maintaining genetic diversity within the species. If other populations are found in the future outside an established MA, an adjacent MA will be extended to include the habitats of those populations, or a new MA should be established based on those populations.

Within MAs, sites where metapopulations and robust, isolated populations occur or will be established are referred to herein as "recovery sites". Recovery sites for metapopulations will include upland and ephemeral aquatic habitats between breeding populations needed for dispersal. "Recovery project sites" are work areas where recovery actions will be carried out. Most project sites will be contained within recovery sites, where we expect most of the recovery work for this frog will occur. However, recovery projects will include watershed improvement projects, signage and other interpretive projects, refugia and holding facilities, rearing facilities, and other activities that may occur outside of recovery sites, or even outside of RUs. Although we expect recovery actions will be focused in MAs, opportunities will likely arise to recover the frog in other portions of the RUs. Delineation of MAs is not meant to deter or limit where recovery can occur.

Recovery actions will often build upon extant populations and previous recovery efforts by restoring habitat and populations to construct functional metapopulations or robust isolated populations. In other areas, metapopulations or individual robust populations will be established where frogs have been absent for many years. Careful evaluation of habitat suitability, including factors such as presence of non-native predators and amphibian chytrid, will be needed to identify potential establishment or re-establishment sites (Appendix D). The conservation and maintenance of all extant populations is critical, as the few extant populations in RUs are typically small and subject to stochastic events that could result in their extirpation. However, some extant populations will disappear despite our best efforts. Loss of some populations should not preclude recovery, as not all extant populations in every RU will likely be needed to meet recovery criteria. Furthermore, successful recovery actions will not necessarily be needed in all MAs, because more MAs are designated for most RUs (2-7 MAs per RU) than are needed to meet recovery criterion 1 (two metapopulations and one isolated, robust population). This redundancy provides flexibility to work where recovery opportunities can be maximized at the least cost, and it builds in a buffer against unexpected losses.

Because recovery must be achieved in each RU, actions or projects that affect frogs or their habitats within a RU are significant in the ESA's section 7 consultation process. As noted in the USFWS's 1998 Consultation Handbook, RUs are population units that have been documented as necessary to both the survival and recovery of the species. Avoiding loss of populations or other serious adverse effects in a RU will ensure continued contribution of that RU to the recovery of the species.

The RUs should not be confused with "distinct population segments" or "DPSs". Vertebrate populations that are "discrete" and "significant" under the Service's DPS policy (61 FR 4722) and designated as DPSs can be considered for listing or delisting. Recovery plans cannot designate a DPS; this requires a rule-making process. The Chiricahua leopard frog RUs, or

portions or groups of RUs, may meet the definition of a DPS; however, we did not design RUs to be DPSs and do not offer an opinion as to whether they meet the criteria for DPSs in accordance with the DPS policy. If recovery and delisting by DPS is deemed desirable in the future, information provided in our RU descriptions and elsewhere in this plan, as well as the outcome of genetic analyses recommended herein (see recovery action 6.14), should help define Chiricahua leopard frog DPSs.

Brief descriptions, a rationale for delineation, and critical recovery needs for each of the eight RUs are presented here. Detailed descriptions, including environmental setting, current and historical occupancy by Chiricahua leopard frogs, land use history, threats, ongoing conservation, and further descriptions of MAs are presented in Appendix B.

Recovery Unit 1: Tumacacori-Atascosa-Pajarito

Description

RU 1 includes the southern Baboquivari Mountains and Altar Valley, Arivaca, and the Tumacacori-Pajarito-Atascosa Mountains (Figure B1, Appendix B). It includes the Sierrita Mountains to the north and mountains to the south in Mexico; the Chiricahua leopard frog is not known from these areas, but they include suitable habitats that are adjacent to other areas with current or historical localities for the frog. The environments represented in RU 1 include oak woodland, oak and mesquite savannas, semi-desert grassland, cienega, and, marginally, Sonoran Desert scrub (Brown and Lowe 1980). The mountains are mostly low, less than 6,000 feet maximum elevation, and the known populations mostly occur at about 4,000 ft (from about 3,500 – 5,000 feet). There are a substantial number of recently confirmed populations, and it appears that several remain as viable populations from Buenos Aires National Wildlife Refuge (BANWR) and the adjoining region of Coronado National Forest, the region of Sycamore Canyon, and, possibly Peck Canyon. At Sycamore Canyon, the Chiricahua leopard frog has survived over three decades since the appearance of chytridiomycosis, and over a decade since American bullfrogs began arriving as unsuccessful invaders. Peck Canyon, which has not recently been resurveyed, may be relatively inhospitable to most harmful introduced species and thus offers recovery potential, as do parts of Pena Blanca Canyon. This information, coupled with the presence of BANWR in Altar Valley, offers an array of potentially successful management options that could lead to recovery within this RU. While elimination of harmful exotics in stock ponds can reasonably be foreseen in this RU, the presence of a variety of harmful, difficult to remove, introduced species at Arivaca Cienega, Arivaca Lake, and Pena Blanca Lake complicates recovery. Three MAs are delineated in Figure B1, Appendix B. These areas are built around existing populations and areas with the greatest potential for population establishment or re-establishment.

Rationale for Delineation

RU 1 encompasses sets of populations that appear to have had migrational connections from Arivaca Cienega, through springs and stock ponds across Altar Valley, Baboquivari Mountains and western Pajarito Mountains, to connected metapopulations centered in Peck Canyon, Pena Blanca Canyon, Sycamore Canyon, and, formerly, California Gulch. These areas are close together and are associated with the Pajarito Mountains. In addition, they share ownership dominated by the U.S. Forest Service, BANWR, and a variety of private, mainly ranching,

interests. These areas also share similar threats – in particular, predation by American bullfrogs, predatory fish and potentially crayfish, and drought effects.

The inclusion of the Sierrita Mountains is based on the presence of stock ponds at elevations suitable for the Chiricahua leopard frog, which could have reached the area by pond-hopping from Arivaca. A former Chiricahua leopard frog population at Maynard Tank at the southwestern base of the Sierrita Mountains also suggests former, if not current, presence in that mountain range. Mountains in Mexico south of the Pajaritos and north of the riverine lowlands from Nogales to Magdalena and Caborca, are at appropriate elevations, and, like the Sierritas, have essentially not been surveyed for leopard frogs. Populations and habitats in RU 1 are separated and disjunct from those in RU 2 by the Santa Cruz River and the Rio Bambuto, which are likely too low in elevation to have supported populations of Chiricahua leopard frogs in recent times.

Crucial Recovery Needs

American bullfrogs are the most difficult problem facing recovery of the Chiricahua leopard frog in RU 1, although crayfish could likely spread from three major sites and become similarly difficult to manage (see threats assessment in Appendix B). The American bullfrog is established in sizable populations at Arivaca Cienega, Arivaca Lake, Ruby, California Gulch, Pena Blanca Lake, a stock pond ("Noviyo") on the west side of Altar Valley, and another (un-named, near Jarillas Tank) in the western Pajaritos, and probably elsewhere. Bullfrogs invade Sycamore Canyon and Pena Blanca Spring regularly, spread six or more miles per year in Altar Valley, and are a colonization threat from Ruby and California Gulch.

Non-native fishes are a threat that could feasibly be alleviated, even on a piecemeal basis. However, there are social and political obstacles to some management that would benefit native ranid frogs in the RU, especially regarding sport fishing at Arivaca Lake, Ruby, and Pena Blanca Lake.

Additionally, chytridiomycosis is apparently well established in Sycamore Canyon, and, given its long tenure there, probably elsewhere. This disease may be less fatal at the lower to moderate elevations occupied by the Chiricahua leopard frog in RU 1. The species has existed with the disease at Sycamore Canyon since at least 1972.

Finally, a number of Chiricahua leopard frog populations have recently occurred in stock ponds that are highly subject to desiccation during serious droughts, and many of these populations have disappeared (at least temporarily) since 2001. The widespread existence of introduced species decreases the quality of stock ponds and confines the Chiricahua leopard frog to suboptimal habitat in this type of environment in RU 1. Thus, a combination of habitat modification (at springs, stock ponds, and lakes, and in dug-out impoundments in cienegas) with introduced species that thrive in modified habitat, is a driving synergy in the threat to the Chiricahua leopard frog in RU 1, and presumably in most or all other RUs.

There are three priority recovery actions in RU 1. First, as the frogs are doing relatively well (though they have markedly declined from presumed original and known historical distribution and abundance) in the Altar-Pajarito region, research should focus on identification of the

characteristics that permit their persistence even though chytridiomycosis and American bullfrogs are strong, observable impacts. Second, the frogs live in natural environments, including major canyon bottom streams, springs, and pools, and the importance of observing and studying this should be stressed. Third, non-native species threats need to be reduced and, where possible, eliminated. This problem comes in several varieties. Stock ponds host many populations of American bullfrogs, which disperse miles on their own, and some problem fish populations, which may be distributed by anglers or others. Stock ponds are so abundant that they are stepping stones for non-native species dispersal. However, it has been demonstrated at BANWR that stock tanks are readily manageable for removal of exotic species (Schwalbe *et al.* 2000). Removal is expensive, time-consuming, and progress can be easily lost if non-native predators are reintroduced in the tank again in the future. New approaches may provide additional strategies for management of non-natives, but elimination of non-natives, especially the American bullfrog, on a landscape-scale large enough to prevent rapid recolonization seems necessary. Once (if) this is accomplished in an area, bullfrog control should expand to surrounding areas to drive out the American bullfrog more rapidly than it can re-colonize the removal areas. During such action, other harmful exotics can be eliminated, and Chiricahua leopard frogs could be established. This work could be conducted solely by the Forest Service, but would best be undertaken with a cooperating team of refuge, ranch, and forest personnel.

Introduced species will likely persist at Arivaca Lake and Pena Blanca Lake during any removal efforts focused on stock ponds; this is also likely, though less intractable, at Ruby Lake and California Gulch. For the large lakes, the first critical step would be collaborative efforts between agencies and stakeholders to build consensus, if possible, that removing American bullfrogs, and possibly crayfish, from the big fishing lakes is a proper and important conservation goal. Recovery will then require the formation of a plan, likely dependant on drought, to eradicate these two most potentially harmful species (even during an extended drought, crayfish in particular will be very difficult to eradicate). Meanwhile, and during any such removal project, an important objective would be to remove all optimal stock pond habitats within dispersal (including human-caused dispersal) range. This could best be accomplished by eliminating deep perennial stock pond waters and replacing them with modern drinkers, although there may be other approaches (see Appendix A).

In the Sonora portion of RU 1, the most immediate needs are to survey for Chiricahua leopard frogs, identify suitable habitats, and identify threats to the species. Opportunities for the protection, enhancement, and management of suitable and potentially suitable frog habitats and populations should then be pursued with CEDES (La Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora), non-governmental organizations, and landowners. If needed, frogs from the Arizona portion of RU1 could be provided to CEDES for translocation into suitable habitats.

<u>Recovery Unit 2: Santa Rita-Huachuca-Ajos/Bavispe</u>

Description

RU 2 includes the headwaters of the San Pedro and Santa Cruz rivers and adjacent mountain ranges in Arizona and Sonora. Southern and western ranges in Sonora also drain into the Rios Sonora, Bavispe, and Magdalena. Vegetation communities range from Chihuahuan Desert scrub

along the San Pedro River to mixed conifer and aspen at the highest elevations. Chiricahua leopard frogs are still relatively well-represented in RU 2. These extant populations are the foundations for seven MAs, which also include adjacent habitats where metapopulations could be built or expanded upon (see Figure B2, Appendix B). Extant populations occur in the Santa Rita and Patagonia mountains, El Bosque Nacional y Refugio de Vida Silvestre Los Ajos-Bavispe (Ajos-Bavispe area), Canelo Hills, San Rafael Valley, Cienega Creek, and upper San Pedro River basin in Sonora. Populations of the Ramsey Canyon leopard frog, tentatively considered here as the Chiricahua leopard frog, also occur on the eastern slope of the Huachuca Mountains.

Rationale for Delineation

RU 2 was designed to encompass what was probably a metapopulation or metapopulations of frogs centered around the headwaters of the San Pedro and Santa Cruz rivers and adjacent mountain ranges in Sonora and Arizona. Historically, frogs probably occurred throughout the unit above about 4,000 feet and interchange among populations occurred among montane canyons and mountain ranges via rivers and associated wetlands and cienegas. The RU was also designed so that land management and recovery efforts could be coordinated via relatively few land managers. In Arizona, management of frogs and their habitats is focused on the Sierra Vista and Nogales Ranger Districts of the Coronado National Forest and adjacent BLM and private lands. The Ajos-Bavispe area and Sierra Mariquita in Sonora are situated in the upper watershed of the San Pedro River, and thus are a natural extension of recovery efforts in the Huachuca Mountains and the upper San Pedro River drainage in Arizona. The southern limits of RU 2 correspond to what we believe may be the southern extent of the range of the Chiricahua leopard frog in this portion of Sonora; however, the distribution of the species in Sonora is poorly known. The species could potentially be found farther south in the Sierra Aconchi or other ranges, but to date Chiricahua leopard frogs have not been found in these areas (Hale 2001). If Chiricahua leopard frogs are found farther south, the boundary of RU 2 should be adjusted to encompass those populations. Seven MAs have been delineated in RU 2 (see Figure B2, Appendix B).

Crucial Recovery Needs

Predation by and spread of non-native predators appear to be the most significant threats to Chiricahua leopard frogs in RU 2 (see threats assessment in Appendix B). Chytridiomycosis is present at several sites and has likely affected persistence of populations. Populations testing positive for the disease have persisted at Cienega Creek, but Ramsey canyon leopard frogs have been eliminated from Ramsey Canyon. The majority of the key habitats for the frog are managed by the Coronado National Forest and are thus afforded some protection, but development pressures elsewhere, particularly in the upper San Pedro River basin of Arizona and Sonora, have and are expected to continue to result in habitat loss and degradation. Wildfire and subsequent downstream ash flow, siltation, and scouring are significant threats, particularly in the Huachuca and Santa Rita mountains. Airborne emissions from copper smelters, and most recently from the smelter at Cananea, likely caused contaminants problems and acidic waters in the past that may have limited opportunities for recovery. The Cananea smelter is now closed; however, if it reopened, effects could remanifest.

Fuels management and wildfire suppression will be important in ameliorating the threat of wildfire. Planning is underway in the Huachuca Mountains to address this threat, and should be expanded to the Santa Rita Mountains. Control or elimination of non-native predators may be possible on a small scale, and public education, improved policies and regulations, and law enforcement can help stem the spread of non-native predators. Currently, our best opportunities to manage this threat are by finding sites in which frogs can be repatriated where non-natives are absent or manageable. Similarly, finding habitats for recovery where amphibian chytrids are absent or frogs can coexist with chytrids is currently the best scenario for dealing with the threat of disease. Research into control of non-natives and amphibian chytrids may expand opportunities for recovery.

The Ramsey Canyon leopard frog Conservation Agreement and Strategy is the best model for recovering the Chiricahua leopard frog in RU 2. Similar working groups for other MAs, or an RU working group to promote and coordinate similar efforts, should be formed to facilitate local recovery. USFWS and other agencies in Arizona should assist SEMARNAT (Mexico's Federal Secretary for the Environment, Natural Resources, and Fisheries) and CEDES in inventory of habitats and frogs, and management needs in the Ajos/Bavispe area and other portions of Sonora in RU 2. Opportunities should be pursued to work with Mexican agencies, non-governmental organizations, and landowners in the protection, enhancement, and management of suitable and potentially suitable frog habitats in the Sonoran portion of RU 2. If needed, U.S. agencies should make available Chiricahua leopard frogs from the U.S. portion of the RU to Mexican partners for population establishment projects in Sonora.

Recovery Unit 3: Chiricahua Mountains- Malpai Borderlands – Sierra Madre

Description

RU 3 is the largest of the eight RUs. From west to east in the U.S., it encompasses the eastern slope of the Mule Mountains across the Sulphur Springs Valley to and including the Chiricahua Mountains, the Swisshelm, Pedregosa, and Perilla mountains, the San Bernardino Valley and the southern San Simon Valley on the Arizona/New Mexico border, east through the southern Peloncillo Mountains and the Guadalupe Mountains (southern end of the Peloncillo Mountains), across the Animas Valley and Animas Mountain into the Playas Valley. In Sonora, the RU includes the Sierra Anibacachi (south of the Mule Mountains), mountains in the headwaters of the Rios Bavispe and Nacozari, including the Sierra Nacozari, Sierra de Opusura, Sierra el Tigre, and Sierra San Luis complex. The RU also includes the northern Sierra Madre Occidental in both Sonora and Chihuahua, south to the Rio Papoqochic near Ciudad Guerrero in west-central Chihuahua. The boundaries of the RU in Sonora and Chihuahua are based on the relatively few records for the species from those Mexican States; however, as discussed in Part 1 of this plan, there are records of leopard frogs from farther south in southern Chihuahua and Durango that may be this species. Depending on the outcome of genetic work and surveys recommended in this plan, the boundaries of RU 3 in Mexico may need to be adjusted to match changes in the recognized range of the species. Five MAs have been delineated in RU 3; these areas include extant populations and have high recovery potential (see Figure B3, Appendix B).

The RU is characterized by sky island basin and range topography in the north, and the northern end of the Sierra Madre Occidental in the south. Vegetation communities range from

Chihuahuan Desert scrub at the lowest elevations through semi-desert and plains grasslands, oak woodlands, ponderosa, and mixed conifer forests at the higher elevations. A relictual stand of petran subalpine conifer forest occurs at the top of the Chiricahua Mountains, and includes Engelmann spruce and trees of the mixed conifer forest.

Chiricahua leopard frogs were historically well-distributed in the Arizona and New Mexico portions of the RU, and at scattered locations in Mexico (Figure 6). The status of populations in Mexico are largely unknown, although frogs have been seen in recent years in the Sierra San Luis complex. The species has declined dramatically in the Arizona and New Mexico portions of the RU. Populations are apparently extirpated from the Sulphur Springs Valley and may be gone from the Chiricahua Mountains. A few populations persist across the San Bernardino Valley and Swisshelm Mountains, Peloncillo Mountains, Animas Valley, and Playas Valley. The species may be extirpated from the Animas Mountains. Chytridomycosis has been documented from populations in the San Bernardino Valley.

Rationale for Delineation

The RU forms a cohesive unit in which frogs likely intermixed broadly among mountain ranges, valleys, and river drainages. It is connected to RU 4 on its northwestern edge and with RU 2 to the west in Sonora. Populations in the Galiuro Mountains and Sulphur Springs Valley in RU 4 probably intermixed with those in RU 3 from the southern Sulphur Springs Valley. However, as described below for RU 4, there are good reasons to place the Dragoon Mountains with the rest of RU 4 from a management perspective. The eastern portions of RU 2 drain primarily to the San Pedro and Santa Cruz rivers and the Rios Sonora and Magdalena, whereas adjacent portions of RU 3 drain to the Rio Bavispe. RU 3 is unique from a management perspective due to the presence of the Malpai Borderlands Group, which is led by a group of ranchers in extreme southeastern Arizona and southwestern New Mexico, which includes the Gray Ranch and nearby private ranches and properties. The Malpai Borderlands Group has a goal of restoring and maintaining the natural processes that create and protect a healthy, unfragmented landscape to support a diverse, flourishing community of human, plant and animal life in the borderlands region. USFWS has developed a Chiricahua leopard frog Safe Harbor Agreement with Malpai. The RU is also unique in regard to issues and threats in the Sierra Madre Occidental, where intensive logging continues to impact conifer forests and watersheds.

Crucial Recovery Needs

The status of Chiricahua leopard frogs in Sonora and Chihuahua is largely unknown and needs to be assessed through surveys at historical localities and other suitable habitats. Surveys should include assessments of threats, and must be closely coordinated with CEDES and other partners, including landowners and communities. These surveys should include genetic analysis of populations in central and southern Chihuahua to determine relationships to the Chiricahua leopard frog. The RU boundaries should be adjusted as needed to match the range of the species. Once populations and opportunities for recovery have been assessed, agencies and non-governmental organizations should seek partnerships to develop and implement appropriate recovery actions.

In the U.S. portion of the RU, disease and predation by non-native species are key threats that need to be addressed. Wildfire threatens the forests and riparian canyons of the sky islands, but

is a lesser threat in Mexico. Effects of livestock grazing continues to be a threat, but is most pronounced in the lower elevations in Mexico. Now that Safe Harbor Agreements are in place with Malpai Borderlands Group and rangewide in Arizona, opportunities for establishing new populations on properties of participating landowners should be pursued. The status of existing populations should be monitored for developing problems, and action taken if factors threaten those populations. In the Chiricahua Mountains, Chiricahua leopard frogs may still occur in Rucker Canyon, near Portal and Cave Creek, or elsewhere. Surveys should be conducted in these areas to determine whether frogs are still extant in that mountain range. If frogs are found, action should be taken, as needed, to ensure their persistence. Similarly, if the landowner grants permission, surveys for extant populations should be conducted in the Animas Mountains. If populations are found, agencies should work with the Animas Foundation to ensure the frog's persistence there. Refugia may be warranted to conserve local or regional demes of frogs.

Recovery Unit 4: Pinaleno-Galiuro-Dragoon Mountains

Description

The dominant features of RU 4 are the three mountain ranges for which the RU is named. The Dragoon Mountains run mostly north-south, south of Interstate 10. The somewhat higher and more mesic Galiuro Mountains lie north of Interstate 10. The Pinaleno Mountains on the northeastern border of the RU are higher (up to 10,720 feet atop Mount Graham) and much more mesic than either the Galiuro or Dragoon Mountains. Between the Dragoon and Galiuro mountains are the smaller Little Dragoon and Winchester ranges. The Sulphur Springs Valley, which drains into the Willcox Playa, is south of the Pinaleno Mountains and east of the Galiuro and Dragoon mountains. RU 4 drains primarily into the Willcox Playa and the San Pedro River. The northern and eastern slopes of the Pinaleno Mountains drain into the Gila River and San Simon Valley, respectively. Portions of that mountain range and the northeastern portion of the Galiuro Mountains drain into Aravaipa Creek, which drains into the San Pedro River. Vegetation communities are highly diverse, ranging from semi-desert and plains grasslands at the lower elevations to the high elevation petran subalpine conifer forests in the Pinaleno Mountains, characterized by Engelmann spruce, corkbark fir, Douglas fir, white fir, and aspen.

Populations of Chiricahua leopard frogs are known historically mainly from the Galiuro and Dragoon mountains, although some locations occurred in the Sulphur Springs Valley, and two disjunct locations were occupied on the northeastern side of the Pinaleno Mountains. "Leopard frogs" were reportedly common in drainages of the Pinaleno Mountains below 4,600 feet (Nickerson and Mayes 1970); however, recent surveys failed to find leopard frogs (personal observations of L.L.C. Jones, Southeastern Arizona/Southwestern New Mexico Stakeholders, 2004). We do not know which species of leopard frog Nickerson and Mayes described as common. Presumed metapopulations occurred in the 1990s in both the Galiuro and Dragoon mountains; however, frogs are currently only known from two sites in the Dragoon Mountains and at only one site in the Galiuro Mountains (Jones and Sredl 2005; USFWS files, Phoenix). Reasons for decline are unknown, but drought in 2002 likely eliminated some stock tank populations. Two MAs, one in the Galiuro and one in the Dragoon mountains, have been delineated in this RU (see Figure B4, Appendix B).

Rationale for Delineation
RU 4 captures the populations and former populations of the Galiuro and Dragoon mountains, which have commonalities from a management perspective. Both ranges supported, until recently, many stock tank populations of Chiricahua leopard frogs, which have largely disappeared in recent years, likely due in part to drying of tanks during drought. Both ranges are managed primarily by the Coronado National Forest. Inclusion of these ranges into one RU makes sense in that recovery actions and stakeholders will be the same or similar. Populations in the Dragoon Mountains were likely connected with populations across the Sulphur Springs Valley to the Chiricahua Mountains in RU 3; however, the species is now absent from that valley. Populations in the Galiuro Mountains may have been more isolated. The populations on the northeastern side of the Pinaleno Mountains may have been disjunct from others in RU 4, or could have been part of a metapopulation of frogs that occurred in lower drainages in that range and may have mixed with populations in the Sulphur Springs Valley.

Crucial Recovery Needs
In comparison to the other seven RUs, the current status of the Chiricahua leopard frog is least secure in RU 4. The species is at risk of disappearing entirely from RU 4 unless immediate action is taken to stabilize populations and ensure their persistence. In 2004, a field trip hosted by the Coronado National Forest's Douglas Ranger District, and attended by AGFD, USFWS, and NMDGF staff, visited former localities and the one known extant population in the Dragoon Mountains at that time. Options were discussed for reestablishing frogs at one or more sites. In 2006, frogs were reestablished at an additional site in the Dragoon Mountains. Further recovery work needs to be pursued as soon as possible. The population at the mine entrance should be monitored regularly for threats to the frogs. Establishing refugia for both the Dragoon and Galiuro populations is warranted to ensure a source of animals for reestablishments in case of extirpation. In the longer term, additional surveys should be conducted to potentially locate other extant populations; former habitats in the Galiuro and Dragoon mountains should be renovated as needed, including provision of dependable water sources; and opportunities for establishing populations at the Muleshoe Ranch (Galiuro Mountains) should be pursued with The Nature Conservancy, BLM, and the Coronado National Forest.

<u>Recovery Unit 5: Mogollon Rim – Verde River</u>

Description
RU 5 lies both above and below the western and central portions of the Mogollon Rim of Arizona. On the west, it is bordered by the Verde River southeast of Camp Verde, to the north the boundary is roughly along the interface between the forested mountains and the grasslands and pinyon-juniper woodlands of the Colorado Plateau. On the east, RU 5 terminates at the border of RU 6, where elevations rise into the White Mountains. The boundary on the south is based roughly on where elevations drop below about 4,000 feet, which corresponds to the presumed lower limit of the frog's distribution in this RU. Above the Mogollon Rim, most drainages flow north or northeast into East Clear Creek, Chevelon Creek, and other tributaries of the Little Colorado River. Below the Mogollon Rim, Fossil Creek, East Verde River, West Clear Creek, and others drain into the Verde River. The vegetation communities of RU 5 are primarily ponderosa and mixed conifer forest, and pinyon-juniper at the lower elevations. Land

management is primarily by the San Carlos and White Mountain Apache Tribes, and portions of the Tonto, Coconino, and Apache-Sitgreaves National Forests.

Historically, there are records of Chiricahua leopard frogs scattered across the western and southern portions of the RU (Figure 6). The relative lack of localities compared to RUs 6-8 may in part reflect a lack of historical survey data, but is also probably a reflection of the relatively dry nature of much of RU 5. Today, the species is confirmed present only at few livestock tanks in the Buckskin Hills area of the Coconino National Forest (Fossil Creek drainage) and on the Tonto National Forest in the Cherry and Crouch creek area near Young and at Ellison Creek. Five MAs have been delineated in RU 5 (see Figure B5, Appendix B).

Rationale for Delineation
Currently extant populations are disjunct from those in RU 6 by over 80 miles and from populations in RU 7 by more than 100 miles. Habitats in RU 5 are lower and drier than in either RUs 6 or 7 to the east. RU 6 is particularly mesic compared to RU 5. Recent genetic evidence and apparent morphology suggest frogs in RU 7 may have closer affinities to frogs in southeastern Arizona than in RU 5. RU 5 is mostly within the headwaters of the Verde, Salt, and Little Colorado rivers; whereas most of RUs 6 and 7 are in the headwaters of the San Francisco and Gila rivers. Our delineation of RU 5 enhances manageability, as there are significant recovery actions underway on the Tonto and Coconino National Forests and opportunities exist for working with the Apache-Sitgreaves National Forests and the White Mountain and San Carlos Apache Tribes.

Crucial Recovery Needs
Extant populations on the Tonto and Coconino National Forests are small and at risk of extirpation due to drought, invasion of non-native predators, and potentially chytridiomycosis (see threats assessment in Appendix B). Several stock tanks populations in the Buckskin Hills of the Coconino National Forest were lost during the 2002 drought. The few that survived have not rebounded, despite recent habitat renovations and relatively good conditions. Chytridomycosis and crayfish occur nearby and are significant threats. Work is underway on both the Coconino and Tonto National Forests to ensure persistence and improve habitats, and momentum for these projects must be continued. Many surveys have been conducted on the National Forests since the species was listed. These surveys need to be continued, particularly in areas where frogs were extant in recent times. Survey training was provided to San Carlos Apache personnel in 2004, and both the San Carlos and White Mountain Apache Tribes have been surveying for frogs. This survey work and additional recovery actions should be encouraged and funded through sources such as the USFWS's Tribal Grants Program. USFWS should provide Chiricahua leopard frogs to Tribes that wish to establish new populations.

<u>Recovery Unit 6: White Mountains-Upper Gila</u>

Description
RU 6 lies across the eastern Mogollon Rim of Arizona into the Gila Wilderness of New Mexico. Elevations are often high and include the 11,403-foot Baldy Peak in the White Mountains and peaks over 10,000 feet in the Mogollon Mountains. The White Mountains contain headwaters of the Little Colorado, White, Black, Blue, and San Francisco rivers. RU 6 also extends northwest

into Silver Creek in the Little Colorado River drainage. In New Mexico, RU 6 includes the San Francisco and Tularosa rivers, which drain into the Gila River; the Gila National Forest, including the Gila Wilderness in the headwaters of the Gila River; southeast to the continental divide in the Black Mountains, and south to almost Silver City. Much of RU 6 is characterized by forested landscapes with many meadows, lakes, streams, and rivers. Most lands in RU 6 are managed by the Gila and Apache-Sitgreaves National Forests. The White Mountain Apache Tribe also manages lands in this RU in the White Mountains of Arizona.

Chiricahua leopard frogs have disappeared from most historical localities in RU 6. In Arizona, the frog is known today from the Black River headwaters, including Three Forks and possibly a recent reestablishment site – Sierra Blanca Lake, with one other possible location in the Black River drainage and a few possible sightings in the upper Blue River area. In New Mexico, Chiricahua leopard frogs are currently known from the San Francisco and Tularosa rivers, the West, Middle, and East forks of the Gila River, the Blue and Dry Blue rivers, and their tributaries. Seven MAs are delineated in RU 6 (see Figure B6, Appendix B).

Rationale for Delineation

RU 6 encompasses the headwaters of the Gila River and the high and relatively heavily-forested montane areas of east-central Arizona and west-central New Mexico. The mesic habitats and many rivers, streams, and other aquatic sites likely allowed movement of frogs throughout this area historically. The RU is distinct from RU 5, which is lower and drier and drains to the Little Colorado, Verde, and Salt Rivers, and recent genetic evidence and apparent morphology suggest frogs to the south in RU 7 may have closer affinities to frogs in southeastern Arizona than in RU 6. RU 8, although containing high mesic forests similar to that in RU 6, drains into the Mimbres and Rio Grande drainages, rather than the Gila River.

Crucial Recovery Needs

Our knowledge of the current status of the Chiricahua leopard frog in some portions of the RU is poor, including the White Mountains, upper Blue River, and Gila Wilderness, among others. These areas need to be thoroughly surveyed to better understand recovery potential and needs. Some local populations or metapopulations are at risk of extirpation and refugia or active management may be needed to ensure their persistence. At Three Forks, crayfish have invaded the pond where frogs breed. This population is the last known natural population in the White Mountains, and perhaps in the Arizona portion of RU 6. The frogs there are not likely to persist in the long-term with crayfish, unless immediate action is taken. Populations in the Deep Creek Divide area of New Mexico have been severly impacted by chytridiomycosis and need immediate recovery actions to ensure the persistence of this deme or metapopulation. The forests in RU 6 are at risk of wildfire due to recent drought and insect damage. Plans are underway to abate wildfire risk; however, many areas are likely to burn in the near term as long as drought persists. Contingency plans need to be developed to ensure persistence of extant populations if wildfire occurs. These plans could include salvage of frogs until threats due to sedimentation, scouring, and ash flow abate, or action plans could be developed to divert such effects away from frog populations. Fire retardants used during suppression, which are toxic to a variety of aquatic organisms, should not be applied in or near the few extant frog populations. Effects of livestock grazing (trampling and degradation of aquatic habitats) continue to threaten populations and need to be addressed.

Opportunities exist for working with a number of partners on recovery actions in RU 6. Survey and other recovery work by the White Mountain Apache Tribe in the White Mountains should be funded and supported through available sources, such as the USFWS Tribal Grants Program. Most currently known extant populations occur on the Gila and Apache-Sitgreaves National Forests. USFWS, NMDGF, and AGFD should work with the Forests to stabilize extant populations and work towards long-term recovery.

Recovery Unit 7: Upper Gila-Blue River

Description

This RU includes portions of the upper reaches of the Gila River and Mule Creek in New Mexico, and the Blue River in Arizona. Major tributaries of the Gila River include Duck Creek, Mangas Creek, and Blue Creek. Major tributaries of the Blue River include Dry Blue Creek and Campbell Blue Creek. Mule Creek and the Blue River are major tributaries of the San Francisco River. Mountain ranges are generally low elevation and mostly small in this region and include the Big Burro, Mule, and Summit Mountains. Vegetation communities range from riparian and Chihuahuan Desert scrub along the Gila River to mixed conifer at the higher elevations. Very few populations of Chiricahua leopard frogs are currently extant in this RU. Only a single small population is known in New Mexico in the Lemmons Peak MA along lower Blue Creek in the Blue hydrologic unit (HU). In Arizona, frogs are extant in two adjacent tributaries of the San Francisco River and a stock tank on the Clifton Ranger District of the Apache-Sitgreaves National Forest. RU 7 includes the following MAs: 1) Lemmons Peak MA including Blue HU, Redrock HU, and Sycamore HU; 2) Mule Creek MA, including Duck HU, Mule HU, and Dry HU; and, 3) Burro Mountain MA, including Swan HU and Mangas HU (see Figure B7, Appendix B).

Rationale for Delineation

RU 7 was designed to include what was probably a metapopulation of frogs scattered along the low elevation tributaries and mainstems of the Gila and Blue rivers. Historically, frogs probably occurred throughout most of the streams and canyons of this unit. Genetic interchange among populations occurred among montane canyons and mountain ranges via rivers and associated wetlands and cienegas. Recent genetic analysis suggests frogs in RU 7 are more similar to frogs in southeastern Arizona than in other central Arizona or west-central frog populations. The RU was also designed so that land management and recovery efforts could be coordinated via relatively few land managers. The Gila and Apache Sitgreaves National Forests administer most of the lands within the boundary of RU 7, although there are BLM and private lands in this RU as well.

Crucial Recovery Needs

Predation by and spread of non-native predators, including crayfish and non-native fishes, are likely the biggest threats to Chiricahua leopard frogs in RU 7 (see threats assessment in Appendix B). Chytridiomycosis is present and has probably eliminated many populations. Most of the key habitats are managed by the Forest Service and BLM and are thus afforded some protection from development. However, water use practices along the lower reaches of the Gila River in the RU will likely result in continued habitat loss and degradation. Livestock overgrazing and the subsequent deterioration of the watershed causing increased flooding,

siltation, and scouring are significant threats, particularly in the Gila-Cliff valley. Wildfire threatens the forests and riparian canyons in RU 7. Research into the control of non-native predators and the spread of chytridiomycosis may provide increased understanding and opportunities for recovery. Opportunities should be expanded for coordinating with non-governmental organizations and landowners for the protection, enhancement, and management of potential frog habitat in RU 7.

Recovery Unit 8: Black-Mimbres-Rio Grande

Description

RU 8 includes streams flowing east (Cuchillo Negro, Palomas, Seco, Animas, and Percha creeks and their tributaries) into the Rio Grande, and south (Mimbres River and tributaries) out of the Black Range. In the south, other tributaries of the Mimbres River (San Vicente Wash, Whitewater Creek, and Lampbright Draw) are included, while to the north, Alamosa Creek (tributary of the Rio Grande), originating in the Plains of San Augustin and southern San Mateo Mountains, Socorro County, New Mexico, is also included within this RU. Most aquatic habitats within RU 8 are either part of the Rio Grande drainage or the Mimbres closed basin. Streams flowing west out of the Black Range are included in RU 6, and are part of the Gila River drainage. Vegetation ranges from Chihuahuan Desert scrub and semi-desert grasslands at lower elevations to mixed-conifer woodlands (primarily ponderosa pine forest) with fir, aspen, and alder at higher elevations. Chiricahua leopard frogs are still relatively well-represented in RU 8. These extant populations are the foundations for four MAs, which will also include adjacent habitats where metapopulations could be built or expanded upon (see Figure B8, Appendix B).

Rationale for Delineation

RU 8 was designed to encompass what is likely a metapopulation or metapopulations of frogs centered around streams of the Rio Grande drainage and Mimbres closed basin along with adjacent mountain ranges in New Mexico. Historically, frogs probably occurred throughout the unit above about 4,430 feet, and interchange among populations occurred between populations on eastern and western slopes of the Black Range over the Continental Divide. In lower elevations as recently as the early 1970's, Chiricahua leopard frogs were widespread along San Vicente Wash and its tributaries, Whitewater Creek and its tributaries, and until the late 1990's in numerous localities along Lampbright Draw and its tributaries. Likewise the species was probably distributed all along the Mimbres River, and tributaries of the Rio Grande flowing east out of the Black Range in suitable microhabitats. The RU was also designed so that land management and recovery efforts could be coordinated via relatively few land managers. Management of frogs and their habitats is focused on the Ladder Ranch, a privately owned property of Turner Enterprises, Inc.; Black Range and Wilderness districts of the Gila National Forest; Chino Mines Company, owned by Phelps Dodge Corporation; and the Monticello Box Water Consortium. The northeastern, eastern, and southeastern borders of the RU constitute the eastern-most limits of the species range in New Mexico. The western border roughly follows the Continental Divide. If Chiricahua leopard frogs are found farther east or south, the boundary of RU 8 should be adjusted to encompass those populations.

Crucial Recovery Needs
Chytridiomycosis and predation by non-native American bullfrogs and crayfish represent the biggest threats to Chiricahua leopard frogs in RU 8 (see threats assessment in Appendix B). Chytridiomycosis has been documented in several historical localities (Seco Creek, Rustler Canyon, Martin Canyon, Lampbright Draw, lower Mimbres River, and Alamosa Warm Springs). In some of those sites chytridiomycosis has decimated leopard frog populations, while other populations within the RU (Alamosa Warm Springs, Lower Mimbres River-Dissert) persist even though they have tested positive for amphibian chytrids. American bullfrogs are encroaching westward along many of the drainages flowing into the Rio Grande, are abundant in the East Fork of the Gila River to the west, and are found in tributaries of the Mimbres River. Crayfish can be found in the Mimbres River, currently in low numbers. Control or elimination of non-native predators may be possible on a small scale, and public education, improved policies and regulations, and law enforcement can help stem the spread of non-native predators. Finding habitats for recovery where amphibian chytrids are absent or frogs can coexist with chytrids is currently the best scenario for dealing with the threat of disease. Research into control of non-natives and amphibian chytrids may expand opportunities for recovery.

Catastrophic wildfire and subsequent downstream ash flow, siltation, and scouring in the Black Range threaten populations in streams with headwaters in those mountains. Fuels management and wildfire suppression will be important in ameliorating the threat of wildfire. Fire retardants used during suppression, which are toxic to a variety of aquatic organisms, should not be applied in or near extant frog populations. Effects of livestock grazing (trampling and degradation of aquatic habitats) continue to threaten populations and need to be addressed.

Most of the key habitats for the frog are on private land (Ladder Ranch, Chino Mines, and Nature Conservancy). Landowners in all three instances are cooperators with leopard frog conservationists and are members of the New Mexico Stakeholders.

Recovery Actions

Twelve broad recovery actions are recommended to achieve Chiricahua leopard frog recovery. These broad actions are stepped-down into discrete activities to which time and cost estimates can be assigned in the Implementation Schedule. Table 1 presents an overview of the 12 actions, demonstrates the relationship of the 12 actions to one or more of the six elements of the recovery strategy, and illustrates how threats associated with the five listing factors (see “Minimization of Threats to the Chiricahua Leopard Frog Through Implementation of Recovery Actions” for a listing of the five listing factors) will be alleviated. Additional information about the recovery actions are found in the Step-down Narrative and the Implementation Schedule.

Recovery of the Chiricahua leopard frog across the eight RUs will require organization and the dedicated work of regional and/or local working groups (recovery action 7.3) to closely monitor Chiricahua leopard frog populations and their habitats (recovery actions 5.1-5.5), implement emergency actions as needed to deal with immediate, serious threats or likely extirpations (recovery actions 1.1-3), while also progressing towards long-term recovery goals and implementation, conducting monitoring (recovery action 5) and research (recovery action 6), and applying the subsequent findings and results to recovery implementation through adaptive

management (recovery action 7.3). Reaching out to the public, Tribes, and Mexican partners to solicit help in the recovery effort while at the same time building support for recovery (recovery actions 7, 8, 10, and 11) will be critical to developing momentum for recovery implementation. Populations of Chiricahua leopard frogs in RUs 4 and 7 are in immediate need of near-term actions to prevent extirpation due to few populations that are small and isolated. Implementation of the recovery strategy and progress toward achieving the recovery criteria may need to wait in these RUs until populations can be stabilized (see recovery actions 1.1-3).

Because populations are often disjunct and small, we expect local populations within metapopulations will exhibit relatively high extinction rates. A critical element to the recovery strategy will be the ability to establish or reestablish populations (recovery action 3), augment existing populations (recovery action 4), and temporarily move frogs out of harm's way in case of environmental disaster (e.g. catastrophic fire or drought) and then repatriate them after the disaster abates (recovery actions 1.2.13, 1.3). State and Federal environmental compliance and coordination to permit these activities should be streamlined and, wherever possible, programmatic compliance to cover human-facilitated movement of frogs within a MA or RU should be sought. Close coordination with land management and wildlife agencies, as well as land owners, ideally through stakeholder subgroups or regional or local working groups, will be needed to make this process work efficiently and in a timely fashion (recovery actions 1.4, 2.3, 4.3, 5.2, 7-9).

Abatement of threats to the Chiricahua leopard frog (recovery actions 1.2 and 2.4-2.7) will often be a difficult process, and remedies for some threats do not currently exist, such as elimination of chytridiomycosis (recovery action 2.6), and control of non-native predators (recovery actions 1.2, 2.4, 2.5, and 2.7), particularly in complex systems. Research is recommended to develop better abatement techniques for these threats (recovery actions 6.13 and 6.19); however, our best strategy will often be to work in MAs and recovery sites where these threats are absent or manageable with current techniques.

The Step-down Narrative describes each of the recommended recovery actions, including cursory guidance on implementation. However, we have left much of the detail of recovery implementation to the Appendices. Appendix A, the Stakeholder's Participation Plan, provides some specific and valuable guidance on how to implement recovery at the MA, recovery site, or project level. Some of this guidance was adapted from the Malpai Borderlands Safe Harbor Agreement for the Chiricahua leopard frog. Other recommendations emerged from Stakeholder Subgroup meetings during the preparation of this plan.

Appendix B expands on the RU descriptions provided in the "Recovery Units" portion of this plan. The material found therein will provide a context for recovery implementation, including critical information about threats within each RU. Ranking of the importance of threats should help working groups focus threat abatement actions in each RU. Appendix D provides guidance on how to establish and augment frog populations, as well as how to establish refugia populations and holding facilities. Guidance is included for selection of potential recovery sites for habitat restoration and population establishment. Once sites have been selected and habitats are restored, the mechanics of how to collect, rear, transport, and release frogs, tadpoles, and eggs can be found in Appendix F.

Survey and preliminary monitoring protocols are found in Appendix E, and additional protocols and monitoring schedules will be developed (recovery action 5.1). Protocols for preventing spread of disease are given in Appendix G. Information on hydrology and riparian ecology (Appendix H) will help guide management of healthy aquatic systems and watersheds. Appendix I contains a set of recommendations for minimizing effects of various types of projects in Chiricahua leopard frog habitats, and mechanisms for compensation for residual effects after all reasonable conservation has been implemented. Guidelines for backyard Chiricahua leopard frog refugia are found in Appendix J.

We have attempted to include as much guidance as possible on recovery implementation. However, application of the guidance will no doubt require that people on the ground find creative solutions to unanticipated problems, so that the goal of this recovery plan can be met in the most efficient way possible. The Step-down Narrative and Appendices should provide significant assistance, but they are not intended to limit or constrain innovative recovery implementation. Such innovation is encouraged in this plan via brainstorming in the recovery team subgroups and working groups, and subsequent adaptive management (recovery actions 7.3 and 12).

Table 1: Major Recovery Actions and Relationships to Recovery Strategy Elements and Listing Factors

Major Recovery Actions	**Implements Recovery Strategy Element(s)**	**Alleviates Threats Associated with Listing Factor(s) #[1]**
1. Protect remaining populations of Chiricahua leopard frogs	1. Protect and manage remaining populations and habitats	A, C, D, E
2. Identify, restore, or create as needed, and protect currently unoccupied recovery sites in each RU necessary to support viable populations and metapopulations of Chiricahua leopard frogs	2. Restore and create habitat, and establish additional populations as needed to build viable metapopulations and isolated robust populations in each RU 5. Develop, support, and build partnerships to facilitate recovery	A, C, D, E
3. Establish new or reestablish former populations at selected recovery sites	2. Restore and create habitat, and establish additional populations as needed to build viable metapopulations and isolated robust populations in each RU 5. Develop, support, and build partnerships to facilitate recovery	A, E
4. Augment populations in MAs as needed to increase persistence	1. Protect and manage remaining populations and habitats 2. Restore and create habitat, and establish additional populations as needed to build viable metapopulations and isolated robust populations in each RU	A, E

5. Monitor Chiricahua leopard frog populations and habitats, and implementation of the recovery plan	3. Monitor progress towards recovery	All
6. Design and implement research needed to support recovery actions and adaptive management	4. Research the conservation biology of the frog with the objective of facilitating efficient recovery	A, C, F
7. Develop support for the recovery effort	5. Develop support and build partnerships to facilitate recovery	All
8. Develop cooperative conservation projects, such as Safe Harbor Agreements and habitat conservation plans, with willing landowners to implement recovery on non-Federal lands	5. Develop support and build partnerships to facilitate recovery	A, B, C, E
9. Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions	All six recovery strategy elements	All
10. Work with Tribal partners to achieve recovery on Tribal lands	All six recovery strategy elements	All
11. Work with Mexican partners to achieve recovery in Mexico	All six recovery strategy elements	All
12. Practice adaptive management in which recovery tasks are revised by USFWS in coordination with the Recovery Team Subgroups as pertinent new information becomes available	All six recovery strategy elements	All

[1]See "Minimization of Threats to the Chiricahua Leopard Frog Through Implementation of Recovery Actions" for a description of the five listing factors and discussion of how the recovery actions alleviate threats.

Narrative Outline for Recovery Actions

1. Protect remaining populations of Chiricahua leopard frogs

   1.1 Identify threats to each extant population

   1.2 Ameliorate threats to each extant population

   1.2.1. Develop recommendations for use and maintenance of watersheds

   Appendix H provides information and suggestions that can be used by land and water managers, ranchers, and others to develop watershed use and maintenance plans for watersheds containing extant populations. Region 3 of the U.S. Forest Service provides additional guidance for watershed, soil, and water conservation (see U.S. Forest Service, Southwest Region 1990, 1992).

   1.2.2. Implement watershed use and maintenance recommendations

   Once developed, recommendations should be implemented on public lands and, in the case of willing private landowners, on private lands. Private and tribal land and water rights will be respected.

   1.2.3. Restore hydrology

   In natural, self-sustaining habitats, the Chiricahua leopard frog depends on functioning aquatic and riparian ecosystems. Appendix H provides information on the inter-relationships among watershed condition, channel processes, and condition and function of aquatic and riparian ecosystems that are maintained by the natural hydrologic regime of low flows, flood flows, and shallow groundwater, including inter- and intra-annual variation. Where natural hydrologic regimes have been interrupted through channel and watershed alterations, including groundwater pumping, aquatic and riparian habitats lose functionality, with commensurate loss of frog habitat. To the extent possible, actions that maximize function of the natural hydrologic regime should be conducted in occupied or potentially occupiable watersheds.

   1.2.4. Restore natural fire regimes in the watersheds of extant populations of Chiricahua leopard frog and in MAs

   Natural fire regimes have been altered throughout the Southwest, resulting in a myriad of changes in watershed and channel processes. Restoration of natural fire regimes has been shown to result in watershed and channel improvements, benefiting riparian and aquatic ecosystems. Where practicable, land managers, ranchers, and others should develop fire management plans for occupied watersheds, including objectives for prescribed fire, managed natural fires, and wildfire that will result in restoration of hydrologic function. As a rule of thumb, to minimize watershed degradation at any one point in time, 20 percent of an occupied watershed should be the maximum area burned through the use of prescribed or other fires in any three-year period. Local conditions, such as watershed condition, slopes, soils, and other factors, may dictate a different percentage to ensure minimization of watershed degradation.

   1.2.5. Identify, minimize, and mitigate contaminants that threaten Chiricahua leopard frog populations

   Watershed use and maintenance plans should identify potential contaminant sources, including point and non-point sources and air-borne sources, and provide strategies for minimizing or mitigating impact of contaminants. See

part 1, “Reasons for Listing/Threats” for a discussion of contaminants that threaten the Chiricahua leopard frog.

1.2.6. Implement guidelines for cattle pond use and maintenance

The “Recommended Minimization Measures”, Part II “Actions Available for Leopard Frog Recovery” in Appendix A and “Livestock Grazing and Management” in Appendix I provide guidance regarding minimizing effects of livestock grazing activities, including cattle pond use and maintenance, on the Chiricahua leopard frog. Land managers, ranchers, and others should be encouraged through the Stakeholders Subgroups to follow these guidelines. Financial and technical assistance should be made available to ranchers and other private landowners for planning and implementation.

1.2.7. Implement guidelines for livestock grazing activities

See Appendix A and I (also see guidance above for 1.2.6).

1.2.8. Enhance bank-line and aquatic vegetation, and habitat complexity at sites with extant populations, where needed

Juvenile frog survivorship is important for population viability. Juvenile survivorship is likely enhanced in aquatic sites with some vegetated banklines and emergent vegetation in which frogs can hide. Aquatic and emergent vegetation are also desirable as egg deposition sites and for cover. Habitat complexity, such as undercut banks, logs, or rocks in the water, and having vegetated shallow water areas for juveniles and deeper more open habitats for adults, also probably increase the likelihood of a healthy population age structure and may insulate the population somewhat from the effects of non-native predators. However, some aquatic sites are prone to becoming overgrown. Open banks can provide important basking and foraging sites, so a mix of open water and vegetated areas is desirable. Ponds completely overgrown with cattails or other emergent plants may exclude viable frog populations. Where these habitat elements are missing or weak, they should be created or enhanced. A mix of open and vegetated banks and waters can be achieved through livestock management or other factors that alter bankline, aquatic, and emergent vegetation. See Appendices A and H for measures that can be taken to assure adequate vegetation cover. Habitat complexity can be enhanced by adding structure (e.g. logs, rocks), and building shallows or deep areas.

1.2.9. Eliminate non-native predators at or near Chiricahua leopard frog populations that pose a threat to those populations

As discussed in Part 1 “Reasons for Listing/Threats”, predation by non-native species is one of, if not the most significant threat to the Chiricahua leopard frog. Bullfrogs and non-native tiger salamanders are also carriers of chytridiomycosis. Bullfrog populations within dispersal distance (roughly five miles overland and seven miles along drainages) and non-native fishes within the same drainage that could be connected via surface waters intermittently or permanently pose a threat to frog populations. Crayfish within four miles along permanent or intermittent drainages are also likely to colonize suitable habitat (Blomquist 2003b). The dispersal ability of tiger salamanders is less well-known in Arizona, but they can probably travel

overland and through drainages for more than a mile. These species may also be moved via anglers, bait collectors, or others from one site to the next. Aquatic sites near popular fishing holes, or that in the past provided fishing or may be readily accessible to the public, are likely to experience introductions of non-native predators. Once introductions are detected, immediate action is needed to control non-natives. If bullfrogs can be eliminated by capture, gigging, or shooting before they reproduce, effective control may be possible. Similarly, if only a few large fish were introduced, they can possibly be removed with a seine or hook and line. Once established, bullfrogs, tiger salamanders, and fish can be eliminated through piscicides, drying of the pond, and other means. Schwalbe *et al.* (2000) and Rosen and Schwalbe (2000) discuss methods to remove non-native fishes and bullfrogs. No effective means are known to eliminate crayfish, once established, although long-term drying of a pond would likely eradicate them. Trapping can reduce populations temporarily, but they will rebound after trapping ceases (Blomquist 2003b). Relationships among species can confound removal efforts. For instance, removal of non-native fishes may result in increased bullfrog or crayfish populations (Rosen and Schwalbe 2002), which may be more difficult to control. Similarly, trapping of large crayfish or removal of adult bullfrogs may result in increased juvenile survivorship and larger populations of small crayfish and bullfrogs. Research will hopefully provide better tools to control non-native predators (recovery action 6.13). Note that native populations of tiger salamanders exist in the San Rafael Valley, Arizona (an endangered subspecies), and along the Mogollon Rim from Arizona into west-central New Mexico. Control of these native salamanders should not be pursued. Any control of non-native predators must be coordinated and permitted through appropriate State, Tribal, and Federal agencies.

1.2.10. Prevent invasion of non-native predators to extant populations

1.2.10.1 Work with AGFD, NMDGF, and FWS to evaluate if stocking of non-native fishes impact extant populations or other recovery activities in MAs, and amend stocking regimes as necessary

Stocking can be intentional and planned by government agencies or the private sector under government permit. Within MAs, AGFD, NMDGF, and FWS should be encouraged to evaluate and amend plans or stipulations of permits to stock non-native fishes at sites within MAs that could impact extant populations of Chiricahua leopard frogs or other important frog habitats (e.g. unoccupied sites or dispersal corridors). Examples of amendments to stocking regimens include changing the species, timing, number, sizes of species stocked, or other actions. Sport fisheries within MAs not directly impacting extant populations or other important habitats may be acceptable if adequate public information and outreach is provided to minimize the likelihood of illegal stocking (e.g. see "Critical Recovery Actions" for RU 1 in "Recovery Units" above).

1.2.10.2. Enforce existing or develop new regulations and policies and outreach to prevent illegal stocking of non-native fish in MAs
Stocking of non-native fishes is illegal in some circumstances. Within MAs, AGFD, NMDGF, and FWS should be encouraged to enforce existing or develop new regulations, policies, and outreach to minimize occurrences of illegally stocked fish at sites within MAs.

1.2.10.3. Regulate use of live bait (crayfish, fishes, frogs, and salamanders) in and near extant populations
AGFD, NMDGF, and other wildlife regulators should be encouraged to enforce existing or develop new regulations as needed that would limit or prohibit the use or transportation of live crayfish, fishes, frogs, and salamanders as bait in MAs. These species (including several species of frogs and tadpoles) are often used by anglers as bait. Release or escape of bait species can result in introductions with potential for predation and spread of disease to Chiricahua leopard frog populations.

1.2.10.4. Enforce existing or develop new regulations and policies to prevent introductions of novel non-native predators within and near the range of the Chiricahua leopard frog
A multitude of non-native fishes, frogs, salamanders, turtles, snakes, crayfish and other invertebrates not currently present in the range of the Chiricahua leopard could potentially be introduced to and become established in the RUs. Many of these species could cause additional predation pressure, spread disease, or alter the habitat of the Chiricahua leopard frog. For example, southern leopard frog tadpoles (*Rana sphenocephala*) are not uncommonly imported into Arizona with stocks of feeder goldfish. These tadpoles could be released and could establish populations within the RUs (Rorabaugh and Sredl 2002). Northern leopard frogs from the eastern United States were until recently commonly sold in pet shops in Arizona and American bullfrog tadpoles are sold at nurseries for people's backyard ponds, both species represent invasive threats. Fishes from the southeastern U.S., Africa, Asia, or elsewhere, imported for the tropical fish trade or other purposes could be released and become established, as could species of crayfish in the pet trade (Inman *et al.* 1998). Such species imported into Arizona, New Mexico, and northwestern Mexico should be evaluated for their potential to adversely affect native species, and then State, Federal, or other regulations or policies should be developed to appropriately regulate/control those importations.

1.2.11. Minimize or eliminate the spread of infectious diseases to extant populations
The spread of chytridiomycosis and other diseases must be controlled and reversed. Use of accepted protocols for the control of pathogens as described in Appendix G is strongly recommended for all field personnel and should be required through State and Federal permitting processes

where such permits are needed for working in aquatic systems (e.g. recovery permits, scientific collecting permits).

1.2.12. Eliminate disease from recovery sites

In order to reestablish sustainable local populations and metapopulations, frogs must be repatriated to historical or newly created habitats that are verifiably free of amphibian chytrids. Needed research described in Section 6 of the recovery narrative would develop techniques to restore or rehabilitate habitats to be used for translocation of Chiricahua leopard frogs. These techniques may include clearing the disease from populations and habitats. Once developed, these techniques would be implemented to allow restoration of viable populations.

1.2.13. Develop and implement contingency plans to ensure persistence of each population or metapopulation in case of environmental disaster (drought, floods, fire, etc)

In cases where populations or metapopulations are at risk of extirpation due to environmental disasters, contingency plans should be developed to ensure population persistence. The recovery team should first identify those populations most at risk, and then develop contingency plans. Abating the threat on-site may involve hauling water to tanks during drought or providing a more dependable water source (e.g. windmill or pipeline), directing post-fire sediment and ash flow away from frog habitats, or other similar measures. Where it is not feasible or possible to abate threats from disasters, frogs/tadpoles should be salvaged and held temporarily, and then repatriated after the danger abates. Protocols for salvaging and temporarily holding frogs or tadpoles can be found in Appendices C, E, and I.

1.2.14. Develop and implement a genetic management plan to maintain or enhance genetic diversity within each RU, where possible

Genetic diversity within populations and metapopulations has not been investigated, but we suspect it is often low due to genetic bottlenecks and frog colonization patterns. Although maintaining genetic diversity is not a recovery criterion, there may be benefits to ensuring genetic diversity is maintained whenever possible. Until genetic diversity can be studied and evaluated across the range of the species, maintenance or enhancement of genetic diversity may best be achieved by maintaining genetic representation, or conservation of extant populations within RUs. Therefore, management activities should be prioritized to conserve genetic representation or diversity whenever feasible, but will not obstruct the ultimate goal of the recovery plan, which is to recover the species. Population establishment/reestablishment and augmentation, in particular, should be conducted in ways that enhance or maintain genetic diversity, while not mixing animals from among local demes. Research into population and metapopulation genetics (recovery action 6.14) will improve our ability to manage genetic diversity.

1.2.15. Enhance carrying capacity of small populations

Populations of less than about 60 adults, or less than 40-50 adults in relatively drought-resistant habitats, are less likely to persist in the long term

or contribute to metapopulation viability. In such populations, actions should be taken to enhance habitat and increase carrying capacity. Appropriate actions will vary with the site and factors limiting population size, but may include increasing water permanency, enhancing bankline cover, increasing the amount of aquatic habitat, reducing predation, or other improvements.

1.2.16. Enhance drought resistance of populations and habitats

Population viability is especially sensitive to the effects of drought. Where possible and feasible, consideration should be given to actions that will ensure population persistence and relative stability through drought. Such actions may include equipping a stock tank with a dependable water source (e.g. windmill or pipeline), deepening a tank or pools, improving watershed condition, etc.

1.2.17. Maintain and restore as needed corridors for frog movement among populations

1.2.17.1. Within metapopulations identify dispersal corridors based on reasonable dispersal distances and geography within each RU

Chiricahua leopard frogs are reasonably likely to disperse about one mile overland, three miles along intermittent drainages, and five miles along permanent drainages. Additional information about dispersal and barriers to dispersal can be found in Part 1 in "Dispersal and Metapopulation Ecology" and "Disruption of Metapopulation Dynamics". For all metapopulations, the recovery team should map out likely dispersal corridors among extant populations and sites selected for population establishment or reestablishment.

1.2.17.2. Develop plans to maintain or restore dispersal corridors where dispersal is beneficial

After dispersal corridors have been identified, plans should be developed to maintain or enhance those corridors. This may include elimination or minimization of non-native predators between aquatic breeding sites. Between or among local populations, barriers to dispersal should be removed, where possible and feasible. Corridors could be enhanced by improving intermittent drainages or providing intermittent pools or impoundments ("secondary sites" – see Part III, Appendix A) between local populations. Maintenance of corridors (ongoing restoration) should be a component of metapopulation planning.

1.2.17.3. Implement plans to maintain or restore dispersal corridors

After the identification of metapopulations with their component local population and corridors, plans developed in 1.2.17.2 must be executed in order to establish viable metapopulations.

1.2.18. Implement conservation and compensation protocols in Appendix I for all projects that may affect extant frog populations

Appendix I contains recommendations for land managers and project proponents regarding appropriate conservation and compensation for a

diverse array of project types. These protocols should be implemented for any project that may affect Chiricahua leopard frog populations, sites selected for population establishment/reestablishment, and identified dispersal corridors among local populations in a metapopulation.

1.3. Establish refugia populations as needed to preserve frog populations in MAs or RUs

Some populations of frogs may be so small or threatened that immediate action is needed to prevent likely extinction. Particularly where such a population is the last in a MA or RU, portions of several egg masses or tadpoles should be collected and reared for establishment of captive refugia as reservoirs of genetic material and animals for recolonization in case of extirpation. Refugia could also be developed as a source of animals for population establishment and augmentation, or to provide animals for research projects. Wild populations could also serve as refugia, if they are actively and intensively managed to ensure long-term persistence. As of this writing, establishment of refugia in RUs 4 and 7 is desirable to prevent loss of the species from those areas. Guidance on establishing refugia or actively-managed populations can be found in Appendices D, F, and J.

2. Identify, restore, or create as needed, and protect currently unoccupied recovery sites in each RU necessary to support viable populations and metapopulations of Chiricahua leopard frogs

2.1. Using selection factors and process, identify and select suitable and potentially-suitable habitats in MAs as recovery sites and for subsequent establishment/re-establishment of Chiricahua leopard frog populations

The "Factors to be Considered in Identifying Sites for Recovery and Population Establishment" in Appendix D should be consulted by the recovery team to screen and select recovery project sites where frog populations will be established or reestablished. Whenever possible, recovery efforts for the Chiricahua leopard frog should dovetail with other recovery efforts or conservation plans to reestablish diverse, native aquatic and riparian ecosystems.

2.2. Identify factors reducing or threatening habitat suitability at each of the selected recovery sites

Once selected, potential threats to recovery (e.g. watershed degradation, invasion of non-native species, chytridiomycosis, etc.) need to be evaluated on the ground and in consultation with land managers, landowners, and other knowledgeable persons. Threats should be assessed by technical experts and stakeholders from the recovery team. Appendix B provides information about some site-specific threats that will be of value in this assessment. We recommend a form be developed to assess and rank potential threats that would be derived from "Reasons for Listing/Threats" in Part 1 of this plan.

2.3. Develop agreements with landowners/managers and complete environmental and other compliance

All environmental compliance (e.g. National Environmental Policy Act (NEPA), ESA compliance, cultural resource compliance, etc.) needs to be completed for treating potential threats identified in 2.2 and for subsequent establishment of Chiricahua leopard frogs. Agreements with willing land- or water-rights holders, such as Safe Harbor Agreements or other agreements, may be needed to provide assurances that those rights are not economically impacted by presence of frogs or recovery actions.

2.4. Treat potentially suitable habitat at recovery sites to eliminate or reduce threats to habitat suitability

Threats identified in 2.2 and for which agreements and compliance were addressed in 2.3, would be abated. Measures to abate threats will depend on the circumstances at each site, but will typically involve measures already discussed above in recovery action 1.2 "Ameliorate threats to each extant population". Appendices A, G, H, and I provide additional information regarding abatement of threats.

2.5. Minimize or eliminate the spread of infectious diseases to recovery sites by implementing disease prevention protocols (Appendix G)

Implementation of disease prevention protocols outlined in Appendix G is imperative to ensure that recovery actions described herein do not result in spread of infectious diseases.

2.6. Eliminate disease from recovery sites by using results of research (6.19) to control/eliminate disease

At sites selected for population establishment where amphibian chytrids have been identified as a threat (recovery action 2.2), research into development of techniques for eliminating chytridiomycosis from populations and habitats will be useful in treating this threat. Treatment may be necessary at the selected site, or at nearby sites within dispersal distance for the organisms carrying or infected with chytridiomycosis.

2.7. Protect selected recovery sites in the same way as habitat supporting extant populations, per part 1 of the Step Down Narrative, above

Once sites have been selected for population establishment/reestablishment, they should be protected in the same ways as extant populations (see recovery actions 1.1-1.4).

3. Establish new or re-establish former populations at selected recovery sites

3.1. Collect eggs, larvae, or frogs from donor site to be used for translocation

Collection of eggs, tadpoles, and froglets for translocation should be conducted to maximize genetic variability of the propagule. This is accomplished by collecting individuals of a variety of developmental stages. Portions of egg masses and accepted proportion of tadpoles should be collected to ensure that collection for the propagule does not adversely affect the source population (if propagule is not obtained from a captive population). Protocols for the collection of different life stages and their transportation are contained in Appendix F.

3.2. Head-start eggs and larvae

Head-starting is a common procedure used in conservation biology for the introduction of individuals into a population. By rearing eggs and larvae in captivity to a later developmental stage, greater survivorship within the propagule, and therefore greater success in translocation, is achieved. Unless new research suggests otherwise, late developmental stage tadpoles or just post-metamorphic frogs are the most desirable propagule composition. Protocols for head-starting eggs and larvae are the same as those for captive rearing contained in Appendix F.

3.3. Release tadpoles/frogs to selected recovery sites

A sufficient number (based on the best current research) of individuals should be selected to constitute the propagule based on source population availability (captive vs. natural) and health protocols described in Appendix F. Pre-release and post-

release activities that will allow assessment of translocation success are included in Appendix F.

4. Augment populations in MAs as needed to increase persistence

4.1. Through population monitoring (5.3) identify sites needing augmentation
One of the objectives of the monitoring plan described in recovery action 5.3 will be to identify those populations that are threatened with population loss due to low population numbers, or for which genetic diversity is thought to be so low that individuals in the population are likely to experience reduced fitness and the ability of the population to adapt to change is compromised. These sites would be targeted for population augmentation.

4.2. Identify a nearby source or donor population that is similar genetically
"Reestablishment, Establishment, and Augmentation of Chiricahua Leopard Frog Populations" in Appendix D provides guidance regarding selection of donor populations. In general, donor populations should come (in order of preference) from within the same MA, the nearest MA within the RU, or from adjacent RUs. Frogs should not be moved between northern (RUs 5-8) and southern (RUs 1-4) recovery units. Care should be taken to prevent movement of amphibian chytrids or chytrid-positive frogs (see Appendix G). The genetic management plan (recovery action 1.2.14) will also be helpful in determining donor populations.

4.3. Develop agreements with landowners/managers
Agreements with willing land- or water-rights holders, such as Safe Harbor Agreements or other agreements, may be needed to provide assurances that those rights are not economically impacted by presence of frogs or recovery actions.

4.4. Complete environmental compliance and documentation
All needed environmental compliance, including NEPA, ESA, cultural resources, and other compliance will need to be completed prior to augmentation.

4.5. Follow steps 3.1-3.3 to augment populations
See narratives for recovery actions 3.1-3.3 regarding mechanics of collection, head-starting, transport, and release of frogs or tadpoles.

5. Monitor Chiricahua leopard frog populations and habitats, and implementation of the recovery plan

5.1. Prepare monitoring schedule and protocol for monitoring populations and habitats, and implementation of the recovery plan
A monitoring protocol should be developed that tracks the following: 1) numbers and occupancy (presence/absence) status of local populations and isolated, robust populations in each RU, 2) qualitative assessment of population size or density, 3) reproductive activity and recruitment in each population, 4) threats to each population, 5) need for population augmentation (recovery action 4) or implementation of disaster contingency plans (recovery action 1.2.13) for each population, and 5) implementation of recovery actions. Monitoring should be conducted no less than annually at each local and isolated/robust population. The monitoring plan should be developed by or in coordination with the recovery team. Prior to plan development, some of the above information can be recorded via the survey and preliminary monitoring protocols presented in Appendix E. The results of monitoring should be reported in the annual recovery team reports (see recovery

action 7.3). We anticipate that the monitoring protocol will also serve as, or will be the basis for, a post-delisting monitoring plan.

5.2. Develop agreements with willing landowners and Tribes to survey for and monitor populations and habitats on non-Federal lands

Agreements for access and monitoring in accordance with the monitoring plan (5.1) should be developed with willing landowners, including Tribes, on non-Federal lands.

5.3. Conduct monitoring

Once monitoring protocols have been developed and agreements with willing landowners are in place, monitoring should be carried out at each population by qualified biologists. Biologists should be properly trained in detecting frogs, assessing threats, and other aspects of the monitoring protocols. If frog populations are found to be in immediate danger of extinction due to drought, fires, or other events, salvage and temporary holding of frogs should be considered (see recovery action 1.2.13 and Appendix D).

5.4. Prepare annual report of monitoring results

The results of monitoring should be reported in the annual recovery team reports (see recovery action 7.3).

5.5. Develop interagency cooperation regarding data sharing and data repository

A database, available to recovery team members and cooperators, should be developed that would include annual reports and a history of monitoring and recovery actions at recovery sites and recovery project sites. Ideally, the database would be web-based and available online. Sensitive data would be available only via password. Data would only be entered, and the website updated, by one or a few entities. Portions of the website could also serve as public outreach (recovery action 7) where anyone could access information about Chiricahua leopard frog recovery.

6. Implement research needed to support recovery actions and adaptive management

6.1. Determine habitat use/needs/selection and home range or territoriality

Habitat selection should be quantified by comparing use versus habitat availability. Seasonality of habitat use/selection by life stage and age class should also be studied. Through telemetry or mark and recapture, home range or territories could be delineated.

6.2. Identify and describe hibernacula

Studies are needed to investigate where the frogs overwinter. Radiotelemetry could be used to locate overwintering frogs. Once located, the characteristics of the overwintering habitat could be quantified. Such studies would help us better understand the habitat needs of the Chiricahua leopard frog.

6.3. Describe oviposition sites

A sample of egg masses would be selected in different aquatic habitat types (lentic, lotic, stock ponds, high/low elevation etc), and then the specific sites where egg masses are deposited would be quantified (e.g. water depth; aquatic, emergent and canopy vegetation types, frequency, and cover; water quality; water temperature; etc). Differences in oviposition sites by age class and season would also be investigated.

6.4. Evaluate dispersal capabilities or seasonal movement in tandem with reestablishment projects

Through telemetry or mark and recapture, movements of resident frogs/tadpoles and released frogs/tadpoles could be examined. Differences in dispersal among age

classes should be evaluated, as well as habitats through which animals are most likely to disperse.

6.5. Examine seasonal changes in activity

Seasonal variation in breeding, dispersal, dormancy, and other behaviors would be examined and quantified by age class.

6.6. Examine response to flooding

Severe flooding has the potential to eliminate populations. Through telemetry, behavior of frogs could be monitored during or after floods. This work may identify safe haven refugia where frogs can survive flooding. Identification of such refugia could be helpful in selecting sites for population establishment, or in habitat enhancement projects.

6.7. Examine feeding and foraging behavior and diet

Behavioral observations would quantify foraging activities, sites, and interactions with other frogs and species, as well as help identify diets. Stomach content of museum specimens and frogs/tadpoles found dead can be used to further quantify diet.

6.8. Examine individual and population response to habitat manipulations

Develop and test designs incorporating vegetation and hydrological components to provide habitat for all stages of Chiricahua leopard frogs (but particularly juveniles) and species on which Chiricahua leopard frogs depend, emphasizing designs that will provide an advantage to Chiricahua leopard frogs over non-native invasive competitors.

6.9. Determine the best life stage for release to the wild

The success of translocating head-started larvae, juvenile, or adult frogs has not been evaluated. Survival and ultimate recruitment to the population, as well as cost, need to be considered. Success should be quantified in terms of survival to maturity and cost.

6.10. Study population and metapopulation dynamics

Long-term population studies should be conducted at selected sites to determine age class distributions, recruitment, age or size-specific mortality, immigration and emigration, and rates of colonization and extirpation in metapopulations.

6.11. Determine age and size at first reproduction and growth rates

In association with recovery action 6.10, age and size at first reproduction for males and females and growth rates of tadpoles and frogs under a variety of conditions and habitat types will be examined.

6.12. Examine interactions with non-native predators and competitors

Laboratory and supporting field experiments will be developed and conducted to examine effects of non-native species (e.g. frogs, fishes, salamanders, and crayfishes) on Chiricahua leopard frog mortality, behavior, growth rates, diet, habitats and habitat use, and other aspects of conservation biology.

6.13. Research and evaluate methods to control non-native predators and competitors

Research is needed to develop cost-effective methods to eradicate or contain populations of non-native predators and competitors, such as American bullfrogs, crayfish, fishes, and salamanders. Research could build upon existing techniques, and could include use of pesticides, habitat modifications and restoration, biological control, and other techniques.

6.14. Examine genetic relationships of populations within and between RUs and within and between metapopulations

Molecular genetics, via microsatellite or mitochondrial DNA analysis, should be conducted to quantify genetic relationships among populations, metapopulations, and RUs. This information will help clarify whether northern and southern populations are different species, and will help define the appropriateness of moving frogs among populations, metapopulations, and RUs. This work should also help define genetic diversity within populations and metapopulations, and the need for augmentation (recovery action 4).

6.15. Conduct Population Viability Analysis (PVA) and/or Population and Habitat Viability Analysis (PHVA)

A PHVA was conducted during the development of this recovery plan (Appendix C). As new information is developed, additional PHVAs or PVA modeling should be conducted. By doing additional PVAs or PHVAs, it may be possible to estimate the number of individuals needed to maintain local populations and metapopulations, or to clarify the importance of certain factors in the viability of populations. This information could be used to improve the recovery strategy, criteria, and actions.

6.16. Develop more effective means to monitor populations

After development and subsequent use of the monitoring protocol (recovery actions 5.1 and 5.3), we will likely find that methods could be refined and made more cost-effective. Research should be conducted as needed to develop more effective monitoring techniques.

6.17. Examine frequency and distribution of disease and die-offs

Through careful monitoring it should be possible to detect die-offs early, investigate their causes, and attempt to remove the threat or salvage individuals from the population.

6.18. Research spread and environmental triggers of disease

Infectious disease vectors, particularly for chytridiomycosis, are not well studied. We suspect, but do not know for certain, that chytridomycosis can be spread by a number of human activities, on the muddy hooves of cattle, or mud on vehicle tires. Disease could also be potentially spread by birds, invertebrates, fishes, or other vectors. Examining mechanisms of disease spread, as well as triggers for disease, will be important in developing effective strategies for controlling or eradicating disease (recovery actions 1.2.11 and 1.2.12).

6.19. Investigate methods to treat chytridiomycosis in wild populations

Continue to communicate with outside researchers about their chytridiomycosis studies. With new techniques, we may be able to clear populations and habitats of chytridomycosis, or strains of frogs may be identified that can survive the effects of the disease. Implement or field test new procedures when appropriate.

6.20. Investigate effects of pesticides and other contaminants on the frog

As described in Part 1 of this recovery plan, leopard frogs and other anurans are affected by a number of contaminants. Airborne pollutants from copper smelters may have adversely affected Chiricahua leopard frogs in southeastern Arizona. The prevalence of contaminants in frog habitats, and the lethal and sublethal effects on Chiricahua leopard frogs should be investigated.

7. Develop support for the recovery effort

7.1. Develop regional recovery working groups that practice broad-based community planning

The concept of implementing this recovery plan throughout the range of the frog in Arizona, New Mexico, and portions of Mexico is daunting. However, if approached from a regional or local level, recovery becomes much more manageable. Local groups, such as Malpai Borderlands Group and the Ramsey Canyon Leopard Frog Conservation Team, are doing a great job at planning and implementing recovery at the local level, and could potentially mentor additional groups. Regional or local working groups could be formed as new independent teams, or may appropriately be committees within existing planning organizations. In any case, recovery working groups at all levels should attempt to involve communities and the public broadly in the recovery effort. Meetings should strive to include and consider all viewpoints, meetings should be open, and the process whereby the group makes decisions should be clearly stated, fair, inclusive, and transparent. Both technical experts and stakeholders should be represented. Finding funding for recovery efforts will often be a huge challenge. However, many agency and private programs, grants, and foundations are available to fund and implement recovery (see Appendix A). As a result, each working group should designate a funding coordinator to identify funding resources, coordinate grant applications, etc. to ensure adequate funding for local recovery efforts. These working groups should be coordinated or facilitated by the recovery team, and appropriate decision makers in agencies and elsewhere should regularly be apprised of the progress and recommendations of these working groups. Such working groups must be linked to the recovery team so the recovery effort will be coordinated, and others working in Chiricahua leopard frog recovery can learn from the experiences of the working groups.

7.2. Post and maintain signs to inform the public of land-use restrictions

At sites of high public visibility and in areas with restrictions to traditional uses on public lands, educational materials should be available to explain the restrictions, how these restrictions fit into other recovery activities in the area, and why they are important to the recovery of this species.

7.3. Develop outreach materials to inform the public and build support for frog recovery

A variety of outreach venues (e.g. listserver messages, a website, paper or electronic newsletter, brochures, posters, calendars, presentations to schools and clubs, television and radio interviews or programs) should be developed with the purpose of building understanding and support for recovery, informing the public of the reasons for and progress towards recovery, and keeping the public abreast of key recovery actions that require public participation (including volunteer activities) to be effective. The public should be encouraged to correct mistakes, or identify issues and propose solutions in the materials presented. Development of outreach materials should consider what may motivate the public to get involved with or support the recovery effort. Where such motives are identified, outreach should provide incentives or an outlet for these motives. Involving an advertising agency or marketing specialist in the development of outreach materials is advisable. The formation of an outreach committee within the recovery team could facilitate development and funding of outreach materials. The outreach committee could also provide a feedback loop to evaluate the effectiveness of the outreach program and

make changes as needed. As a first step, several brochures should be produced and written for public distribution to educate the public about recovery activities that agencies are undertaking, how individual actions can contribute towards recovery of this species, and ways interested publics can help. The initial brochure should provide identification information, goals of the recovery plan, and the means to implement the recovery actions in laymen's terms. Additional brochures or posters concerning the effects of non-native predators on native ranids, release of pets, water conservation, and the use of native species for mosquito control should all be considered by the outreach subcommittee. An important issue to be raised in the brochures is educating the public that release of non-native species, whether they are unwanted pets, fish bait, or other unwanted animals, is illegal and may spread diseases to, or cause predation of, Chiricahua leopard frogs and other sensitive species. Funding for outreach should be through contributions of management agencies, grants, and voluntary contributions to specific projects. Findings and recommendations of the Populations and Habitats Working Groups from the PHVA Workshop regarding public outreach should be incorporated into any outreach program or campaign (see Appendix C).

7.4. Continue momentum for recovery through the Stakeholders and Technical Subgroups of the Recovery Team

An annual joint meeting of the Stakeholders and the Technical Subgroups should be held between November and March to review the current status of the species, recovery plan accomplishments, develop plans for the next fiscal year, and discuss needed adaptive management. Additional working groups may also organize and meet at the RU or MA level to develop and implement regional recovery planning. An outreach subcommittee within the recovery team should be organized, as well. This subcommittee should consist of members of the Stakeholder and Technical subgroups. While the goal of outreach should be to promote recovery of the Chiricahua leopard frog, when appropriate, members of the outreach subcommittee should seek opportunities for disseminating information on the conservation of other native ranid frogs and species to promote conservation of these other species to help avoid the need to list them. Opportunities to promote recovery of the frog through existing outreach mechanisms or avenues should be sought. For instance, the Forest Service and BLM hold annual meetings with grazing permittees; these meetings provide excellent opportunities to discuss conservation and recovery, and to develop potential recovery projects. Natural Resource Conservation Service (NRCS) staff provide extension services to ranchers and farmers, through which additional opportunities could be developed. Annual progress reports should be produced by the recovery team (Stakeholders and Technical Subgroups). The reports should summarize: 1) recovery plan implementation for the previous year, 2) work plans for the upcoming year, and 3) recommended changes to recovery implementation (see recovery action 12 – adaptive management).

7.5. Amplify efforts by expanding to include coalitions with other species and ecosystem projects

Recovery efforts for the Chiricahua leopard frog will often align with conservation of other aquatic or riparian species, such as native fishes, other native frogs, gartersnakes, snails, California floater, rare plants, and the southwestern willow

flycatcher. For instance, control of non-native predators is often a part of the strategy for recovering native fishes and gartersnakes. Recovery project proposals are more likely to be funded if they address conservation of a suite of species or an ecosystem. By joining forces with other recovery efforts we can amplify recovery of all species by sharing resources. Some caution is warranted to ensure that the complexity and number of partners in these larger efforts do not become unwieldy from a planning perspective; controversy surrounding another species does not derail recovery of the frog; and, that these efforts do not otherwise subsume or sideline recovery of the frog.

8. Develop cooperative conservation projects, such as Safe Harbor Agreements and habitat conservation plans, with willing landowners and water-rights holders to implement recovery on non-Federal lands

8.1. Seek out willing partners through the Stakeholders Subgroups and other venues

Through members of the Stakeholders Subgroups, brochures (see 7.2 and 7.3, above), websites (see recovery action 5.5), and other venues, the recovery team and participating agencies should seek partners for implementing and funding recovery actions. Landowners and water-rights holders in MAs will be especially important to contact and develop cooperative recovery projects. Willing partners may include non-Federal interests that can provide funding or match Federal funding to cover costs of certain recovery actions.

8.2. Develop agreements with willing parties

Once willing partners have been identified, agreements with such partners (e.g. Safe Harbor Agreements, permits, etc.) should be identified and developed as needed.

9. Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions

Federal and State land managers, as well as cooperating non-governmental organizations such as The Nature Conservancy, should amend planning documents as needed to facilitate implementation of this recovery plan. Broad land-use plans, such as Forest Plans or BLM Resource Management Plans, may not need revision, as they often include language stipulating that agencies will strive to implement recovery for Federally-listed species. Program level or area-specific plans, such as habitat management plans, wilderness and Area of Critical Environmental Concern plans, and grazing plans, including allotment management plans and annual operating plans, are an opportunity to work with Stakeholders to build in detailed planning at the MA or even recovery site level. We encourage land managers to work closely with RU or MA Stakeholder and Technical Subgroups (see recovery actions 7.3 and 12) on revision of such plans.

10. Work with Tribal partners to achieve recovery on Tribal lands

10.1. Support work by Tribal biologists to survey potential habitats on Tribal lands and to better determine the distribution and status of the frog

USFWS and other recovery partners should provide regular training to Tribal biologists regarding survey and monitoring protocols for Chiricahua leopard frogs, provide Tribes with access to the data repository (recovery action 5.5), and seek opportunities to help Tribes fund recovery actions. USFWS should encourage and assist the White Mountain Apache and San Carlos Apache tribes in developing applications for Tribal Landowner Incentive and Tribal Wildlife grants programs. If Tribes do not have populations of Chiricahua leopard frogs to work with, State and

Federal agencies should make available frogs from refugia or other donor sites for population establishment/reestablishment that Tribes wish to pursue.

10.2. Develop partnerships with Tribes to implement recovery actions

USFWS should develop MOUs with the White Mountain and San Carlos Apache Tribes to define roles, potential funding resources, and other elements necessary to facilitate recovery of the Chiricahua leopard frog on Tribal lands (see Mogollon Rim Stakeholder's section of Appendix A).

11. Work with Mexican partners to achieve recovery in Mexico

11.1. Support work by Mexican biologists to survey potential habitats in Mexico and determine the distribution and status of the frog in Mexico

Provide regular training to Mexican biologists regarding survey and monitoring protocols for Chiricahua leopard frogs. Mexican biologists, agencies, and other partners would have access to the data repository and would be encouraged to provide data from Sonora and Chihuahua for inclusion into the database. U.S. agencies with authority to work with Mexico on recovery should use their authorities to provide expertise, funding, equipment, and other resources for Mexican biologists to begin a complete inventory of suitable habitats in the range of the Chiricahua leopard frog, and to identify threats to extant populations and sites with high recovery potential.

11.2. Develop partnerships with Mexican agencies and landowners to implement recovery actions

U.S. agencies and other partners should seek willing partners with Mexican agencies, landowners, and non-governmental organizations to implement recovery for the Chiricahua leopard frog. Because of the extent of private lands, developing good working relationships with communities, landowners, ejidatarios (owners of ejidos), and non-governmental organizations is essential. Public outreach, similar to that described in recovery action 7, should be extended to Sonora and Chihuahua, including development of brochures in Spanish that cater to the needs of potential Mexican partners and the public.

12. Practice adaptive management in which recovery tasks are revised by USFWS in coordination with the Recovery Team Subgroups as pertinent new information becomes available

Adaptive management is a process whereby the recovery plan is revised based on relevant new information suggesting that recovery can be achieved more efficiently or sooner if the recovery strategy, actions, or other elements of the plan are revised. In this recovery plan, adaptive management has two facets or levels. First, the results of monitoring and research will, respectively, track plan implementation and provide potentially new or revised management approaches to facilitate recovery. Any aspect of the recovery plan may need to be revised to include or adapt to this information. Secondly, the recovery plan may need to be adapted to local or site-specific conditions and situations. We have attempted to anticipate all obstacles and opportunities for recovery at the site-specific level, but Stakeholder and Technical Subgroup members working in specific areas may encounter situations that require departure from the recovery strategy or actions to achieve timely and efficient recovery at the MA or RU level.

We envision RU and potentially MA teams of stakeholder and technical expertise working together to implement and monitor the implementation of this recovery plan. These local teams would feed information to regional Stakeholder and Technical Subgroups of the recovery team. The recovery team would then make specific recommendations, as needed, in annual reports to USFWS to revise the recovery plan in response to monitoring data and research results. If recommended changes to the recovery plan do not represent a major change in the recovery direction (i.e., changes do not indicate a shift in the overall direction of recovery), then it can be considered an "update" and does not require a public review and comment period. Copies of the updated pages would be forwarded to the recovery team and other cooperators and posted on USFWS websites. If recommended revisions constitute significant modification in the direction of the recovery plan, then a "revision" of the plan is warranted, and public review and comment would be sought. Changes to recovery actions will likely require only an update; these changes should be made and implemented as soon as possible. Changes in the recovery strategy and criteria will often warrant a revision, and should be addressed in 5-year reviews.

The implementation schedule runs for only five years. In year five, the recovery team should evaluate progress to date and needed adaptive management, and make a recommendation to the USFWS regarding whether the plan needs revision or if the implementation schedule can be "updated" to extend the schedule for another five years. If only an update is warranted, the team's recommendation to the USFWS should include the updated implementation schedule.

Minimization of Threats to the Chiricahua Leopard Frog through Implementation of Recovery Actions

The final rule listing the Chiricahua leopard frog evaluated threats to the species in terms of 5 listing factors. To recover the Chiricahua leopard frog, the threats identified in the listing factors must be reduced or eliminated. Recovery actions comprise the mechanism by which threats will be addressed. A tabular portrayal of the relationship between the twelve major recovery actions and the threats/listing factors they address is presented in Table 1. Several of the actions (#5, 7, 9-12) address all five listing factors. Recovery action 5, monitoring, is key in identifying problems and threats, and tracking implementation of the plan; and therefore is of value in ameliorating threats associated with all five listing factors. Recovery action 7, developing support for the recovery effort, will be critical to achieving political momentum for overcoming political and administrative barriers to recovery, as well as to obtaining funding for recovery actions. Recovery actions 9-11 involve broadly working with Tribes and Mexican partners, as well as in land-use planning, to implement the recovery plan. Recovery action 12 is adaptive management, which is necessary to ensure effective recovery implementation based on the best information available. Below we provide additional discussion by listing factor regarding how each recovery action will address threats.

<u>Listing Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.</u>

The final rule listing the Chiricahua leopard frog as a threatened species (67 FR 40790) found that "Riparian (in or associated with wetted areas) and wetland communities throughout the range of the Chiricahua leopard frog are much altered and/or reduced in size compared to early-

to mid-19th century conditions" and furthermore "dams, diversions, groundwater pumping, introduction of non-native organisms, woodcutting, mining, contaminants, urban and agricultural development, road construction, overgrazing, and altered fire regimes have all contributed to reduced quality and quantity of riparian and wetland habitat." The rule also finds that elimination of beavers from many streams and rivers in Arizona and New Mexico likely reduced pool and pond habitat for Chiricahua leopard frogs.

This recovery plan proposes recovery actions to ameliorate or eliminate these threats to the Chiricahua leopard frog. However, because of the difficulty or lack of effective methods to currently deal with some threats, such as non-native predators in complex systems, chytridiomycosis where it is already established in a system, potential climate change, and existing dams and major diversions, our strategy has often been to identify and locate MAs and recovery sites where such threats are absent or manageable. In regard to climate change, most RUs contain substantial elevational and microsite variability, which will help buffer them against potential higher temperatures and changes in precipitation levels or patterns.

At recovery sites, threats would be identified and ameliorated (recovery actions 1.1 and 1.2), including such actions as restoring and maintaining watershed function, implementation of livestock grazing and cattle pond guidelines, elimination of non-native predators and prevention of further introductions, contingency plans in case of unavoidable disasters (e.g. floods, drought, fires), restoration and maintenance of dispersal corridors, and implementation of conservation protocols for surface-disturbing projects that may affect the Chiricahua leopard frog and its habitat (Appendix I). Where habitats have been reduced or altered by past activities, we propose to conduct habitat restoration (recovery action 2) and reestablish frogs at those sites (recovery action 3). These actions would be taken in close coordination with landowners and managers, and would be facilitated by Safe Harbor Agreements, Habitat Conservation Plans, and other land-use planning tools.

In regard to curtailment of the frog's range, this recovery plan aims to ameliorate threats (recovery actions 1 and 2), conserve existing populations (recovery action 1), and establish and reestablish or augment populations where needed to establish viable populations and metapopulations (recovery actions 3 and 4) in all eight RUs. By addressing recovery in each RU, the Chiricahua leopard frog will be well-distributed throughout its historical range when recovered.

<u>Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.</u>

Although, as indicated in the final rule, there is some evidence that collection may occur, overcollection or overutilization of Chiricahua leopard frogs is not known to be a significant threat to this species. Enforcement of current State and Federal (U.S. and Mexico) regulations prohibiting the collection or take of this species should be adequate to ameliorate any threat that overcollection or overutilization may pose. Stakeholders and herpetologists working in MAs will provide necessary on-the-ground presence in sensitive areas and will alert law enforcement of any suspected illegal activities (recovery action 5 – monitoring). This presence and existing regulatory mechanisms currently preclude the need for specific recovery actions addressing this

potential threat. If overcollection is identified as a threat in the future, appropriate recovery actions will be identified in coordination with the Technical and Stakeholders Subgroups and included in this plan via adaptive management.

Listing Factor C: Disease or Predation.

The final rule identifies predation by non-native introduced American bullfrogs, fishes, tiger salamanders, and crayfish as perhaps the most important factor in the current decline of the Chiricahua leopard frog. As discussed under listing factor A, we do not know how to eliminate or control non-native predators in complex aquatic systems, and it is costly to eliminate them from even simple systems like a cattle tank. As a result, MAs are often located where non-native species are manageable or absent. Recovery action 1.2.10 calls for elimination of non-native predators at or near Chiricahua leopard frog populations, where such predators pose a threat to frog populations. Recovery action 1.2.11 is designed to prevent invasion of non-natives into extant frog populations. Selection criteria for recovery sites, where frog populations would be established, include careful evaluation of the potential for predation by non-natives and rejection of sites where this threat is not manageable (see "Factors to be Considered in Identifying Sites for Recovery and Population Establishment" in Appendix D). Where predation is manageable, action would be taken to ameliorate that threat (recovery action 2.4, and also see the previously referenced section). For MAs with significant non-native predation problems for which we currently do not have adequate control methods, we propose research and development of such methods. Recovery action 6.13 calls for development of methods to eliminate non-native predators. Recovery actions 1.2.10 and 2.4 would employ the results of this research to eliminate non-native predators from extant populations and other recovery sites.

Similarly, for chytridiomycosis, we attempt to focus recovery in areas and recovery sites where amphibian chytrids are absent. By employment of disease prevention protocols (recovery actions 1.1.12.1 and 2.5.1, and Appendix G) we hope to minimize spread of chytridiomycosis or other potentially threatening diseases to recovery sites and project areas. Avoidance of the disease threat will not always be possible, particularly where there are extant frog populations that are known to be amphibian chytrid positive. In addition, factors beyond our control may result in spread of disease to currently healthy populations. We currently do not know how to manage or eliminate chytridiomycosis in frog populations. As a result, recovery action 6.4 calls for research and development of methods to eliminate or minimize disease. Recovery actions 1.2.13 and 2.6.1 call for using the results of such research to eliminate disease from extant populations and other recovery sites.

Listing Factor D: The Inadequacy of Existing Regulatory Mechanisms.

The final rule notes that a variety of laws and regulations provide some protection to Chiricahua leopard frogs and their habitats, but that when taken together they had not stemmed habitat loss and degradation or adequately addressed factors such as introduction of non-native predators. When the species was listed, significant new regulations to protect the species were put in place. Pursuant to the ESA, collection and other forms of "take", possession, sale or offer to sell, delivery, transport, transport in interstate or foreign commerce in the course of a commercial activity, and import or export of the Chiricahua leopard frog became prohibited acts. Permits

may be issued to carry out otherwise prohibited activities under certain circumstances. Through the section 7 consultation process, measures are often developed and implemented to protect or minimize effects to the species and its habitat.

When recovered, the frog will no longer have the protections now afforded under the ESA. However, the recovery plan recommends development of new policies, agreements with landowners and managers, and amendment of land use plans and other documents to ensure regulatory and other mechanisms will provide for the protection of the species and its habitat into the foreseeable future. For instance, recovery action 1.2.10.4 recommends enforcement of existing regulations and development of new regulations and policies to prevent introductions of novel non-native predators within and near the range of the frog. Recovery action 1.2.10.1 recommends evaluation and modification of fish stocking regimes that could impact Chiricahua leopard frog populations. Recovery action 1.2.10.3 aims to regulate use of live bait (crayfish, fishes, frogs, and salamanders) near extant frog populations. Recovery actions 1 and 2, and Appendix I (conservation protocols) provide substantial guidance that will be of use in development or amendment of land use plans, habitat management plans, and other plans that may affect or benefit the frogs and its habitat (see recovery action 9). While still listed, this same guidance will be of value in developing Safe Harbor Agreements and Habitat Conservation Plans (recovery action 8) with non-federal partners, but also with Federal agencies as measures in section 7 consultations to reduce effects of Federal activities.

Listing Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence.

Chiricahua leopard frog populations and the environs they inhabit are often small and dynamic. Populations are subject to extirpation from random variation in demographics, disease, and natural events such as flooding and drought. Metapopulations can buffer the effects of small populations, but these groups of populations are susceptible to disease (see *Disruption of Metapopulation Dynamics* in Part 1 of this Plan).

To address the susceptibility of small populations to random events, flooding, and drought, the recovery strategy described herein aims to build at least two metapopulations in each RU. These metapopulations should be in different drainages to reduce the chance that floods, fires, or other watershed events that could devastate both metapopulations. Furthermore, we recommend establishing at least one robust but isolated population in each RU that would provide a buffer in case disease wiped out one or both metapopulations. Actively-managed or captive refugium populations would be established in some RUs and could be used to replenish other populations in a RU in case of extirpation or decline. Refugia and any reestablishments from those refugia would be managed in accordance with the genetic management plan to ensure minimal loss of genetic diversity. Recovery action 1.2.14 recommends development of contingency plans to ensure persistence of each population and metapopulation in case of drought, floods, fire, or other environmental disasters.

PART III. IMPLEMENTATION SCHEDULE

The implementation schedule outlines the tasks discussed in Part II and indicates task numbers, priorities, durations, estimated costs, and partners that may be involved in implementing the task. If accomplished, these tasks should enable the Chiricahua leopard frog to be delisted. The costs for each task are estimates, and actual budgets will have to be determined when each task is undertaken. Recovery plans are non-regulatory documents, and as such, identified partners are not obligated to implement recovery tasks. Cost estimates do not commit funding by any agency.

Action priorities in the implementation schedule are assigned as follows:

Priority 1:	An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
Priority 2:	An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
Priority 3:	All other actions necessary to provide for full recovery of the species.

Priorities are based in part on the immediacy and severity of specific threats, as determined by the threats assessments presented in Appendix B, and how each recovery action would ameliorate those threats. We have attempted to provide an overall priority for each recovery action that applies across recovery units. However, threats, and therefore the importance of recovery actions that ameliorate those threats, vary by RU. Assessment of threats by RU is presented in Appendix B and should also be used to help guide recovery action priorities within each RU. Task duration in Column 4 indicates the number of years required to complete the task. A continuing task will continue to be conducted once implemented. An ongoing task is one that is already being conducted.

The following abbreviations are used to indicate the responsible party for a given action (cooperating parties are shown in parentheses):

AGFD	Arizona Game and Fish Department
ASDM	Arizona-Sonora Desert Museum
BLM	Bureau of Land Management (AZ, NM)
CNF	Coronado National Forest
FTHUA	Fort Huachuca
FWSES	Fish and Wildlife Service Ecological Services, Phoenix and Albuquerque
FWSR	Fish and Wildlife Service – Refuges (Buenos Aires and Leslie Canyon National Wildlife Refuges)
GNF	Gila National Forest
CEDES	La Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora
LMS	a collective term for land managers, including BLM, NFs, FTHUA, FWSR, NFs, SCAT, SSG, TNC, and WMAT
NFs	Coronado, Gila, Coconino, Tonto, and Apache-Sitgreaves National Forests

NMDGF	New Mexico Department of Game and Fish
NRCS	Natural Resources Conservation Service
PhZ	Phoenix Zoo
RES	Researchers from AGFD, NMDGF, Universities, CEDES, SCAT, WMAT, Forest Service Range and Experiment Stations
RCLFCT	Ramsey Canyon Leopard Frog Conservation Team
SCAT	San Carlos Apache Tribe
SSG	Stakeholders Subgroups
TNC	The Nature Conservancy
TSG	Technical Subgroup of the Recovery Team
WMAT	White Mountain Apache Tribe

Tasks identified for implementation by SCAT and WMAT are tentative and would be further defined in Memoranda of Agreements between USFWS and the Tribes pursuant to Secretarial Order 3206 to define recovery implementation parameters.

IMPLEMENTATION SCHEDULE

Costs (thousands of dollars)

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
1.1	Identify threats to each extant population	1	Continuing	AGFD, FWSES, CEDES, LMS, NMDGF, TSG, TNC	5	5	5	5	5	25
1.2.1	Develop recommendations for use and maintenance of watersheds	1	1 yr	BLM, CEDES, NFs, NRCS, SCAT, SSG, TSG, WMAT	1	0	0	0	0	1
1.2.2	Implement watershed use and maintenance recommendations	1	Continuing	LMS	2	2	2	2	2	10
1.2.3	Restore hydrology	1	Continuing	LMS, NRCS	20	20	20	20	20	100
1.2.4	Restore natural fire regimes in the watersheds of extant populations of Chiricahua leopard frogs and in MAs	1	Continuing	LMS, NRCS	50	50	50	50	50	250
1.2.5	Identify, minimize, and mitigate contaminants that threaten Chiricahua leopard frog populations	2	Continuing	FWSES, LMS	20	20	20	20	20	100
1.2.6	Implement guidelines for cattle pond use and maintenance	2	Continuing	LMS, NRCS	10	10	10	10	10	50
1.2.7	Implement guidelines for livestock grazing activities	1	Continuing	LMS, NRCS	10	10	10	10	10	50

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
1.2.8	Enhance bankline and aquatic vegetation, and habitat complexity at sites with extant populations, where needed	2	Continuing	LMS, NRCS	5	5	5	5	5	25
1.2.9	Eliminate non-native predators at or near Chiricahua leopard frog populations that pose a threat to those populations	1	Continuing	AGFD, FWSES, CEDES, LMS, NRCS	20	20	20	20	20	100
1.2.10.1	Work with AGFD, NMDGF, and FWS to evaluate if stocking of non-native fishes impact extant populations or other recovery activities in MAs and amend stocking regimes as necessary	1	3 yrs	AGFD, FWSES, NMDGF, SSG, TSG	1	1	1	0	0	3
1.2.10.2	Enforce existing or develop new regulations and policies and outreach to prevent illegal stocking of non-native fish in MAs	1	Ongoing/ Continuing	AGFD, NMDGF, FWSES	5	5	5	3	3	21
1.2.10.3	Regulate use of live bait (crayfish, fishes, frogs, and salamanders) in and near extant populations	1	Ongoing/ Continuing	AGFD, NMDGF	5	5	5	5	5	25
1.2.10.4	Enforce existing or develop new regulations and policies to prevent introductions of novel non-native predators within and near the range of the Chiricahua leopard frog	2	Ongoing/ Continuing	AGFD, FWSES, CEDES, NMDGF, SCAT, SSG, TSG, WMAT	5	5	5	5	5	25

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
1.2.11	Minimize or eliminate the spread of infectious diseases to extant populations	1	Ongoing	All	10	10	10	10	10	50
1.2.12	Eliminate disease from recovery sites	2	5 yrs	AGFD, BLM, FWSES, FWSR, NFs, NMDGF, NRCS, SSG	10	10	10	10	10	50
1.2.13	Develop and implement contingency plans to ensure persistence of each population or metapopulation in case of environmental disaster (drought, floods, fire, etc)	2	5 yrs	AGFD, NMDGF, FWSES, SSG, TSG, LMS, PhZ, ASDM	15	15	15	15	15	75
1.2.14	Develop and implement a genetic management plan to maintain or enhance genetic diversity within each RU	2	Continuing	AGFD, ASDM, FWSES, CEDES, NMDGF, PHz, TSG, SCAT, WMAT, USGS-BRD	5	3	3	3	3	17
1.2.15	Enhance carrying capacity of small populations	2	5 yrs	AGFD, FWSR, CEDES, LMS, NRCS, NMDGF, SSG	20	20	20	20	20	100

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
1.2.16	Enhance drought resistance of populations and habitats	2	5 yrs	AGFD, FWSR, CEDES, LMS, NRCS, NMDGF, SSG	15	15	15	15	15	75
1.2.17.1	Within metapopulations, identify dispersal corridors based on reasonable dispersal distances and geography within each RU	1	2 yrs	AGFD, FWSES, CEDES, LMS, NMDGF, TSG	5	5	0	0	0	10
1.2.17.2	Develop plans to maintain or restore dispersal corridors where dispersal is beneficial	1	2 yrs	AGFD, FWSES, CEDES, LMS, NRCS, NMDGF	4	4	0	0	0	8
1.2.17.3	Implement plans to maintain or restore dispersal corridors	1	Continuing	AGFD, FWSR, CEDES, LMS, NRCS, NMDGF, SSG	0	0	TBD	TBD	TBD	TBD
1.2.18	Implement conservation and compensation protocols in Appendix I for all projects that may affect extant frog populations	1	Continuing	LMS	20	20	20	20	20	100
1.3	Establish refugia populations as needed to preserve frog populations in MAs or RUs	1	Continuing	AGFD, ASDM, BLM, FWSES, FWSR, NFs, NMDGF, PHz, SSG	20	20	5	5	5	55

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
2.1	Using selection factors and process, identify and select suitable and potentially suitable habitats in MAs as recovery sites and for subsequent establishment/reestablishment of Chiricahua leopard frogs	2	3 yrs	AGFD, FWSES, CEDES, LMS NMDGF, NRCS, RCLFCT	5	5	5	0	0	15
2.2	Identify factors reducing or threatening habitat suitability at each of the selected recovery project sites	2	3 yrs	AGFD, FWSR, CEDES, LMS, NMDGF, NRCS	0	3	3	3	0	9
2.3	Develop agreements with landowners/managers and complete environmental and other compliance	2	3 yrs	AGFD, FWSES, CEDES, LMS, NMDGF	0	10	10	10	0	30
2.4	Treat potentially suitable habitat at recovery project sites to eliminate or reduce threats to habitat suitability	2	3 yrs	AGFD, NMDGF, LMS	0	0	TBD	TBD	TBD	TBD
2.5	Minimize or eliminate the spread of infectious diseases to recovery sites by implementing disease prevention protocols	2	Continuing	All	5	5	5	5	5	25
2.6	Eliminate disease from recovery sites by using results of research (6.19) to control/eliminate disease	2	3 yrs	AGFD, SSG, FWSES, CEDES, LMS, NMDGF	0	0	TBD	TBD	TBD	TBD

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
2.7	Protect selected recovery sites in the same way as habitat supporting extant populations, per recovery action 1 above	2	Continuing	LMS	TBD	TBD	TBD	TBD	TBD	TBD
3.1	Collect eggs, larvae, or frogs from donor sites to be used for translocation	1	5 yrs	AGFD, (BLM), FWSR, FWSES, CEDES, (NFs), NMDGF, RCLFCT, SCAT, SSG, TSG, WMAT	3	3	3	3	3	15
3.2	Head-start eggs and larvae	2	5 yrs	AGFD, ASDM, FWSR, CEDES, PhZ	15	15	15	15	15	75
3.3	Release tadpoles/frogs to selected recovery sites	2	5 yrs	AGFD, (BLM), FWSR, FWSES, CEDES, (NFs), NMDGF, SCAT, WMAT	10	10	10	10	10	50
4.1	Through population monitoring (5.3) identify sites needing augmentation	2	Continuing	AGFD, FWSES, FWSR, CEDES, NMDGF, SCAT, SSG, TSG, WMAT	3	3	3	3	3	15

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
4.2	Identify a nearby source or donor population that is similar genetically	2	Continuing	AGFD, FWSES, FWSR, CEDES, NMDGF, SCAT, SSG, TSG, WMAT	1	1	1	1	1	5
4.3	Develop agreements with landowners/managers	2	Continuing	AGFD, FWSES, LMS, NMDGF	3	3	3	3	3	15
4.4	Complete environmental compliance and documentation	2	Continuing	AGFD, FWSES, NMDGF, SCAT, WMAT	5	5	5	5	5	25
4.5	Follow steps 3.1-3.3 to augment populations	2	Continuing	AGFD, (BLM), FWSR, FWSES, CEDES, (NFs), NMDGF, SCAT, WMAT	5	5	5	5	5	25
5.1	Prepare monitoring schedule and protocol for monitoring populations and implementation of the recovery plan	2	1 yr	AGFD, FWSES, FWSR, CEDES, SCAT, WMAT	10	0	0	0	0	10
5.2	Develop agreements with willing landowners and Tribes to survey for and monitor populations on non-Federal lands	2	2 yrs	AGFD, FWSES, CEDES, NMDGF, WMAT, SCAT	3	3	0	0	0	6

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
5.3	Conduct monitoring	2	Continuing	AGFD, FWSES, FWSR, CEDES LMS, NMDGF, NFs	TBD	TBD	TBD	TBD	TBD	TBD
5.4	Prepare annual report of monitoring results	2	Continuing	SSG, TSG,	5	5	5	5	5	25
5.5	Develop interagency cooperation regarding data sharing and data repository	2	2 yrs	AGFD, FWSES, CEDES, NMDGF	2	2	0	0	0	4
6.1	Determine habitat use/needs/selection and home range or territoriality	3	3 yrs	RES	0	15	15	15	0	45
6.2	Identify and describe hibernacula	3	3 yrs	RES	0	10	10	10	0	30
6.2	Describe oviposition sites	2	3 yrs	RES	0	5	5	5	0	15
6.4	Evaluate dispersal capabilities or seasonal movement in tandem with reestablishment projects	2	5 yrs	RES	10	15	30	15	10	80
6.5	Examine seasonal changes in activity	1	3 yrs	RES	8	8	8	0	0	24
6.6	Examine response to flooding	2	3 yrs	RES	0	5	5	5	0	15
6.7	Examine feeding and foraging behavior and diet	1	3 yrs	RES	0	5	5	5	0	15
6.8	Examine individual and population response to habitat manipulation	2	4 yrs	RES	5	10	10	10	0	35

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
6.9	Determine the best life stage for release to the wild	3	3 yrs	RES	10	10	10	0	0	30
6.10	Study population and metapopulation dynamics	3	5 yrs	RES	10	15	15	15	15	70
6.11	Determine age and size at first reproduction and growth rates	2	5 yrs	RES	5	5	20	10	5	45
6.12	Examine interactions with non-native predators and competitors	2	5 yrs	RES	10	20	20	20	20	90
6.13	Research and evaluate methods to control non-native predators and competitors	1	5 yrs	RES	30	30	30	30	30	150
6.14	Examine genetic relationships of populations within and between RUs and within and between metapopulations	1	3 yrs	RES	25	15	20	0	0	60
6.15	Conduct Population Viability Analysis (PVA) and/or Population and Habitat Viability Analysis (PHVA)	1	1 yr	TSG, SSG	8	0	0	0	0	8
6.16	Develop more effective means to monitor populations	2	3 yrs	RES, SSG, TSG	15	15	15	0	0	45
6.17	Examine frequency and distribution of disease and die-offs	3	3 yrs	RES	15	15	15	0	0	45
6.18	Research spread and environmental triggers of disease	2	5 yrs	RES	15	15	15	10	10	65

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
6.19	Investigate methods to treat chytrids in wild populations	1	5 yrs	RES	15	20	20	15	15	85
6.20	Investigate effects of pesticides and other contaminants on the frog	2	2 yrs	RES	0	15	15	0	0	30
7.1	Develop regional recovery working groups that practice broad-based community planning	1	5 yrs	TSG, SSG	20	15	15	15	15	80
7.2	Post and maintain signs to inform the public of land-use restrictions	2	5 yrs	LMS	20	20	20	20	20	100
7.3	Develop outreach materials to inform the public and build support for frog recovery	1	5 yrs	LMS, SSG, TSG	20	20	5	5	5	55
7.4	Continue momentum for recovery through the Stakeholders and Technical Subgroups	1	5 yrs	SSG, TSG	2	2	2	2	2	10
7.5	Amplify efforts by expanding to include coalitions with other species and ecosystem projects	2	5 yrs	LMS, SSG, TSG, AGFD, NMDGF, FWSES	5	5	5	5	5	25
8.1	Seek out willing partners through the Stakeholders Subgroups and other venues	1	5 yrs	AGFD, FWSES, NMDGF, NRCS, SSG	3	3	3	3	3	15
8.2	Develop agreements with willing parties	2	5 yrs	AGFD, FWSES, NMDGF, NRCS, SSG	3	3	3	3	3	15

Task	Description	Priority	Duration	Responsible Party	FY 1	FY 2	FY3	FY 4	FY 5	Total
9	Amend land use plans, habitat management plans, and other plans as needed to implement recovery actions	2	5 yrs	LMS	40	40	40	40	40	200
10.1	Support work by Tribal biologists to survey potential habitats on Tribal lands and to better determine the distribution and status of the frog	2	5 yrs	WMAT, SCAT, FWSES	20	20	20	20	20	100
10.2	Develop partnerships with Tribes to implement recovery actions	2	5 yrs	WMAT, SCAT, FWSES	5	5	5	5	5	25
11.1	Support work by Mexican biologists to survey potential habitats and determine the distribution and population status of the frog in Mexico	1	5 yrs	CEDES, FWSES, AGFD, NMDGF	20	20	20	20	20	100
11.2	Develop partnerships with Mexican agencies and landowners to implement recovery actions	2	5 yrs	CEDES, FWSES, AGFD, NMDGF	10	10	10	10	10	50
12.	Practice adaptive management in which recovery actions are revised by USFWS in coordination with the Recovery Team Subgroups as pertinent new information becomes available	2	5 yrs	SSG, TSG, FWSES, CEDES, SCAT, WMAT	3	3	3	3	3	15
FY Totals					**710**	**739**	**763**	**637**	**564**	
Grand Total					**$3,413,000.00**					

These totals are minimum cost estimates that do not include TBD costs.

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APPENDICES

(A – M)

APPENDIX A

Participation Team Plan for Implementing the Chiricahua Leopard Frog (*Rana chiricahuensis*) Recovery Plan

The purpose of the Participation Plan (plan) is to describe a means to carry out the tasks and actions described in the Implementation Schedule of the Chiricahua Leopard Frog Recovery Plan. This plan is directed to existing and future wildlife and land managers so that they may consider incorporating Chiricahua leopard frog recovery actions into daily management activities and resource plans. We focus on those actions that can be funded economically by land-use activities, grants, cost-share programs, and donations.

Section I of the plan briefly describes the Stakeholder Subgroups who developed this plan. Section II describes general actions land managers can take to support the recovery plan's strategy elements of protecting existing populations, establishing new and re-establishing former populations, abating threats and known causes of decline, and maintaining and protecting habitat. Many of these actions may apply across all eight RUs within the range of the species. However, the range of the species is diverse and subject to substantially varied threats and opportunities. Section III of this plan therefore discusses unique circumstances and opportunities in each of the eight RUs. Section IV identifies a preliminary list of resources that may be useful for information, technical guidance, and project funding. Section V provides information on the process used to develop this plan, and Sections VI and VII provide contact information and concluding statements.

I. MEMBERSHIP AND ORGANIZATION OF THE STAKEHOLDER SUBGROUPS

The Recovery Team divided the range of the Chiricahua leopard frogs into eight RUs. The recovery plan contains a description of each unit, rationale for delineation, and critical recovery needs. A map of RU boundaries appears as Figure 1 in the recovery plan. Additional detailed information about each RU is found in Appendix B (e.g., descriptions, maps, and a threats assessment for each RU). To address the various circumstances throughout the range of the frog, three Stakeholders Subgroups were formed: Mogollon Rim (RU 5, and Arizona portions of RUs 6 and 7), Southeastern Arizona/Southwestern New Mexico (RUs 1, 2, 3, and 4), and West-Central New Mexico (RU 8, and New Mexico portions of RUs 6 and 7). The Southeastern Arizona/Southwestern New Mexico Stakeholders Subgroup also addressed potential issues and concerns in adjacent portions of Sonora and Chihuahua where the Chiricahua leopard frog occurs. However, no landowners or managers from Mexico have been able to attend the meetings of the Subgroup. Rafaela Parades and Eduardo Lopez formerly of IMADES, Hermosillo, Sonora, were involved in the recovery plan preparation and identified issues, threats to the frog, and recovery needs in Mexico, which have been incorporated into the recovery plan and appendices.

II. ACTIONS AVAILABLE FOR CHIRICAHUA LEOPARD FROG RECOVERY

To ensure implementation of the recovery plan, it is necessary to provide site and project-specific direction for conservation actions. The following recommendations can be used throughout the range of the Chiricahua leopard frog; recommendations specific to unique regional circumstances are also discussed below.

The Metapopulation Concept and Biological Objectives

The recovery plan recommends managing most remaining Chiricahua leopard frog populations as "metapopulations." A metapopulation is an assemblage of smaller, local populations that are sufficiently close to each other to allow migrational interchange. In a metapopulation, local populations may fluctuate or even be periodically extirpated, but the metapopulation remains intact because the processes of emigration and immigration replenish local gene pools. The recovery plan also recommends establishment of isolated but robust populations in each RU as buffers against disease, and establishment of refugia or actively-managed populations where immediate action is needed to prevent likely extinction in a MA or RU. The recovery plan also describes development of RU and MA-specific Chiricahua leopard frog management plans.

Currently, the greatest opportunities for ranchers and land or water managers to participate in the recovery of the Chiricahua leopard frog lies in management of livestock tanks in a manner that will provide sustainable habitat for frogs and other wildlife while serving their intended purpose of providing water for livestock. Water levels, bank-line vegetation, non-native predators, and other habitat features and threats are more manageable in these systems than in streams, rivers, and lakes. This recommendation is not intended to downplay the importance of more natural habitats, which typically provide more habitat and more stability over time than livestock tanks. However, from the perspective of stakeholder participation, livestock tanks will often provide the best opportunities for recovery plan implementation. Because of this, the following discussion focuses on livestock tank management within the context of creating metapopulations, isolated but robust populations, and captive or actively-managed refugia, in accordance with the recovery strategy and the recovery actions. However, several recommendations address natural habitats, and land managers will find that some of the information provided regarding stock tanks is applicable to other types of aquatic systems. Land managers will also find many of the recommendations useful in managing elk in leopard frog habitat. Additional guidance regarding restoration, management, and population establishment for streams, rivers, lakes, and other natural systems can be found in Appendices G and H.

Based on the above, the Participation Plan identifies three biological objectives:

(A) To manage, establish, and distribute a system of "primary" and "secondary" leopard frog population sites within each RU, such that biological contact between local populations within each metapopulation is maintained (i.e., stock tanks and other aquatic sites that support leopard frogs should be within reasonable dispersal distance (see Appendix K) of each other);

(B) To manage, establish, and distribute Chiricahua leopard frog populations within RUs, such that sufficient distance between sites supporting leopard frogs and those supporting American bullfrogs and other non-native predators and disease is maintained (this will help prevent disease and migration by non-native predators into leopard frog habitat); and,

(C) To manage for the primary importance of maintaining metapopulation structure. In other words, while each local leopard frog population is important, it is the metapopulation that is essential. The occasional loss of individual leopard frog populations as a result of biological, climatic, economic, or other factors may therefore be acceptable, so long as the affected metapopulation persists.

Population Site Definitions

We anticipate that Chiricahua leopard frog populations will often, if not most likely, be managed and maintained primarily within aquatic sites constructed or operated for stock watering purposes. While such sites in some cases will consist of natural waters such as streams or springs, most will be artificial stock tanks. In either case, two types of leopard frog population sites are defined:

(A) *Primary Sites*. A primary (or core) site is defined as a relatively permanent water source of about ¼ acre in size or more. A permanent water source will have a reliable water supply (e.g., a well or spring) and will typically retain water—or, at the least, subsurface moisture—year-round in all years. An ideal artificial primary site would be an earthen stock pond with a double tank and an auxiliary water supply fed by a well. Another type of primary site might consist of a single large or an aggregated group of concrete or steel "drinkers" fed by a well and set with a float valve to ensure a constant water supply. Furthermore, primary sites should also have terrestrial travel corridors or connectivity to secondary sites that will facilitate movement of frogs between sites. The primary criteria for a primary site are the amount, reliability, relative permanence of water, and the extent to which frogs can move from a primary site to neighboring sites. Primary sites will serve as frog population sites from which translocation stock can be obtained, and from which natural emigration to other sites can occur.

(B) *Secondary Sites*. A secondary site is defined as a water source that is typically smaller than a primary site and/or one that may occasionally go dry. A secondary site would typically be expected to hold water year-round on an average of one year out of two (i.e., 50 percent of years overall). A typical secondary site would be any stock tank configuration fed directly by run-off or by a storage tank fed by run-off (run-off-fed tanks hold water less reliably than well-fed or spring-fed tanks), or intermittent stream segments. Leopard frogs will most likely occupy secondary sites during wet years or seasons, via natural migration, as opposed to reestablishment or translocation. An ideal location for a secondary site would be in or near a natural travel corridor such as a creek bottom or draw. Small "drinker" type configurations in such corridors would be ideal secondary sites.

Reestablishment and Distribution Criteria

Key elements of the recovery program will include the maintenance of existing leopard frog populations within each RU; the establishment of new populations through leopard frog reestablishment, translocation, and natural migration and dispersal; and the enhancement of suitable habitats. The term "establishment" means the movement of leopard frogs into a recovery site from outside an MA; the term "translocation" means the movement of leopard frogs from one recovery site to another within an MA.

Appendix D provides criteria for selecting recovery project sites for establishment or reestablishment of Chiricahua leopard frogs and should be consulted in conjunction with Appendix A. The criteria provided should be used to screen potential recovery project sites. We believe only "primary sites" as defined above will meet the criteria for population establishment or reestablishment. Primary sites are the same as "local populations" in the definition of "metapopulation" in the glossary (Appendix K). Once sites have been selected, further guidance is provided below regarding management of these sites. This guidance is designed to achieve the biological objectives described above and to establish and maintain suitable metapopulation dynamics through natural leopard frog colonization, dispersal, and interchange. However, in practice this may be difficult to achieve, at least in the early years of the program, and active management of leopard frog populations, including artificial interchange through ongoing reestablishment and translocations, as well as augmentation, will likely be necessary. Specific management guidance is as follows:

(A) Buffer areas should be maintained between aquatic sites currently supporting American bullfrogs, non-native fishes, crayfish, and chytrids and any newly established primary leopard frog population sites. Translocations should not occur within habitats where there is a risk of colonization and/or predation from American bullfrogs, non-native fishes, crayfish, or chytrids. Buffers from American bullfrogs should consist of a minimum of five miles overland distance between waters with American bullfrogs and primary sites, and a minimum of seven miles distance between waters with American bullfrogs and primary sites within drainage lines. A buffer site of at least four miles should be maintained between crayfish populations and primary sites.

(B) A suitable mix of primary and secondary sites should be maintained. Primary sites are needed as refugia for leopard frogs during periods of seasonal dry weather and long-term drought, to provide areas to which frogs from secondary sites can move during such periods, and to provide sites from which recolonization can occur. Secondary sites are important as aids to natural dispersal during wet years and because primary (i.e., permanent and semi-permanent) sites will be relatively scarce and alone may not be sufficient to maintain a healthy metapopulation.

(C) To the maximum extent practicable, leopard frog distribution within each metapopulation should: 1) consist of a mixture of at least four primary and additional secondary stock tank or other aquatic sites, and at least one population site for each 4-16 square mile area; 2) contain primary sites within five miles of one or more other primary sites; 3) contain primary sites that are self-sustaining with minimal management (e.g. minimal or no

augmentation, predator control, and habitat maintenance over a 15-year period); 4) include a system of continuous population corridors consisting typically (but not exclusively) of secondary sites located in, near, or adjacent to travel corridors (e.g., natural drainage lines) and spaced at 1-2½ mile intervals to encourage and support natural frog dispersal; and 5) include a combination of aquatic habitats, including natural and manmade systems.

(D) Prior to reestablishment or translocation of leopard frogs into any aquatic site, the site should be inspected for suitability, and the following suitability criteria should be satisfied to the maximum extent practicable: 1) demonstrated absence, at the time of reestablishment or translocation, of American bullfrogs, predatory fish, crayfish, tiger salamanders (unless native), and chytridiomycosis; 2) low risk of colonization by American bullfrogs, non-native fishes, crayfish, chytrids, or tiger salamanders, including a minimum of five miles overland distance and seven miles in-drainage distance from known American bullfrog populations, and four miles from crayfish populations; 3) presence, typically, of water year round; 4) presence of emergent vegetation; 5) for concrete or steel tanks, a means for frogs to get into and out of the tank and permanent or semi-permanent water depths of at least 18 inches; and 6) presence of suitable water quality. Although specific leopard frog water quality tolerances are not currently known, waters should not be anoxic, should not exhibit high sulfide levels, and should exhibit pH levels of no lower than 6.0 or higher than 9.0 (see Part 1: "Diseases and Contaminants" and "Loss and Degradation of Habitat" for discussions of how water quality affects frogs). Specific decisions concerning water quality suitability should be reviewed with knowledgeable technical experts familiar with the local area.

(E) Sources of leopard frogs for reestablishment and translocations will be determined by USFWS and State Game and Fish Department personnel, but will likely include existing leopard frog populations within each RU when possible, refugia, rearing facilities at zoos and museums, and *in situ* rearing facilities (e.g., on-site aquatic sites that are protected from predators from which young leopard frogs can disperse naturally to nearby population sites). Leopard frogs typically will be reestablished or translocated at the egg mass, tadpole, or metamorph stage. State and Federal licenses and permits are required to transfer and hold leopard frogs.

(F) Leopard frog reestablishments, translocations, and augmentations should be conducted in a manner that: 1) maintains, to the maximum extent practicable, genetic diversity within each leopard frog metapopulation; and 2) prevents disease transmission. To accomplish these two criteria, genetic management guidelines (see recovery action 1.2.14.) and Disease Prevention Protocols (Appendix G), respectively, will be implemented.

Recommended Measures to Enhance Success

The combined use of stock tanks, springs, and streams for livestock watering and as leopard frog habitat raises four areas of potential concern: (A) the impacts of stock tank maintenance on leopard frogs; (B) the impacts of livestock use on leopard frogs and habitat quality; (C) the potential for introduction of disease or predatory aquatic species into ranch aquatic systems, and

(D) the impacts of land treatments such as prescribed fire and herbicide applications. These concerns are discussed below with recommendations for reducing potential effects of these activities on the leopard frog. Also see Appendices H and I for additional recommendations.

Stream Habitat Management
Riparian habitat should be managed to attain and maintain Proper Functioning Condition (PFC). PFC is a state of resiliency that will allow a riparian-wetland system to hold together during a 25- to 30-year flow event, sustaining the system's ability to produce values related to both physical and biological attributes.

Stock Tank Maintenance
For earthen, run-off fed tanks, maintenance activities consist primarily of periodic removal of accumulated sediment via bulldozer, backhoe, or other heavy equipment. This is required approximately once every 5-20 years and is typically accomplished when the tank is dry or almost dry, in some cases requiring deliberate drying of the tank. Where leopard frogs are present, this would likely result in frogs being forced to vacate the tank, or in death or injury to frogs that remained in the tank. However, tank maintenance ultimately benefits land managers and leopard frogs, since earthen tanks would otherwise fill with sediment and lose their value as frog habitat. Other types of tanks (e.g., steel or concrete) may also need periodic drying for maintenance purposes, though heavy equipment use in these cases is less likely, and leopard frogs can be captured for holding relatively easily in these types of tanks.

Stock tanks requiring maintenance should be thoroughly surveyed for leopard frogs if they support suitable habitat. Surveys should occur prior to maintenance in accordance with the survey protocol in Appendix E. Special care should be given to surveying dry or nearly dry tanks. In these situations, frogs may take refuge in cracks or holes, or hide under logs or rocks around the edges of dry or drying stock tanks. If leopard frogs are found to occupy the stock tank, the protocols outlined in the recovery plan Appendix F (Protocols for Captive Care, Transportation, and Release of Leopard Frogs [*Rana* sp.]) and Appendix I (Conservation Protocols) should be considered and implemented.

Maintenance and management of stock tanks will often increase water permanency. However, from the perspective of frog conservation, managers should be cautious about increasing the permanency of aquatic frog habitats too much. Many leopard frog populations occur where there are nearly perennial, yet primarily intermittent stock ponds that are close to excellent drought refugia such as spring-fed streams or lines of tinajas in a canyon. The ponds may produce the most successful reproduction, whereas the less productive streams and tinajas provide ultimate refuge and also contribute to individual survival and reproductive success because of the additional habitat diversity, which may cause success to occur on different schedules than may occur in the ponds. The occasional to frequent drying of the ponds is often critical to preventing harmful non-natives, especially the American bullfrog, from gaining an upper hand. Natural flooding or other conditions in the stream or tinaja canyon may also be important in preventing American bullfrogs and many non-native fish from becoming established. However, some fishes, especially green sunfish, and also bullhead catfish, may do well even in canyons adjacent to stock tanks, and their removal by poison or other methods is advisable wherever feasible.

Stock Tank Best Management Practices
Stock tank best management practices vary from situation to situation, and each occupied tank will present a unique set of problems and solutions. It is generally recommended, when funds, labor, and the situation warrants, that managers consider partial fencing of occupied stock tanks, complete fencing of occupied stock tanks with a drinker, or the gradual replacement of occupied single tanks with "trick-tanks." Implementing any combination of these actions would enhance vegetation, prevent trampling, decrease water degradation, and minimize the spread of chytridiomycosis. When livestock tanks are newly constructed or reconstructed, consideration of how that tank may serve as a stepping stone for non-native species to move across the landscape and negatively affect leopard frog recovery is important. Careful placement of tanks and regulating public access may be necessary to ensure tanks do not become reservoirs of non-native predators. Also consider whether these tanks can serve as habitat restoration/creation sites for future establishment or re-establishment of leopard frog populations. Converting stock tanks to troughs or elevated tanks in which water is supplied by a pipeline, windmill, or solar pump should be considered if the site is expected to be colonized by non-native predators, but should be discouraged if it could serve as a habitat for leopard frogs.

Livestock Use
Livestock use of stock tanks is a normal and expected activity at aquatic sites under this Participation Plan, including sites that support leopard frog populations. While livestock and frog use of aquatic sites is generally compatible, careful management of livestock use at tanks occupied by leopard frogs will be essential to recovery. Absent such management, livestock use could result in destruction or deterioration of leopard frog habitat through excessive trampling, destruction of egg masses and vegetation, and fouling of water quality. Livestock use could also inadvertently result in transmission of chytridiomycosis. This might occur if the disease was present in the area and was spread by livestock, wildlife, or humans moving from infected to uninfected sites (see Part 1 of the Plan, "Habitat Degradation and Loss").

Introduction of Predatory Species
The colonization of leopard frog habitats by non-native aquatic predators, whether by natural dispersal or by deliberate or inadvertent introduction is an ever-present threat to Chiricahua leopard frog populations. Non-native predators adversely affect leopard frog populations by preying on tadpoles, metamorphs, young frogs, and possibly egg masses. American bullfrogs and tiger salamanders are often unaffected by chytridiomycosis but can serve as carriers, spreading the disease among sites. Presence of these species often results in the extirpation of leopard frogs from otherwise suitable habitat. Consequently, prevention or minimization of such introductions and control of non-native predators where they occur, as described below, are essential features of the Participation Plan. However, such measures must also be implemented and timed in such a fashion that necessary land manager operations are not significantly prevented or disrupted.

Land Treatments
Rangeland managers often desire to apply periodic disturbances, such as prescribed fire, herbicide applications, and chaining or grubbing, to control shrub invasion and maintain current seral stages. These activities usually disturb vegetation cover and can expose soils to increased erosion. Subsequent runoff can carry increased sediment loads, along with ash and other

contaminants into aquatic habitats. Sedimentation and ash can kill eggs and larval frogs and decrease the life or otherwise negatively affect the value of the aquatic habitat. This would necessitate increased need to maintain the tank and increase the potential for mortality or injury of individual frogs. In addition, herbicides can have a variety of effects on ranid frogs, and even at very low levels, have been implicated in endocrine system disruption in leopard frogs. While these activities may be beneficial to the upland terrestrial habitats, they may result in short-term detrimental effects to aquatic habitats down slope. The planning of these land treatments should consider buffers around aquatic habitats and best management practices to reduce the amount of erosion and runoff that enters aquatic habitats. Land managers are encouraged to work with NRCS, USFWS, State agency or other personnel to develop effective minimization measures on a case-by-case basis, where applicable. Also see recommendations in Appendix I.

In light of the above considerations, we recommend that land managers implement the following measures at sites supporting leopard frog populations on their lands and at sites where populations will be established or reestablished:

(A) (i) Conduct routine stock tank maintenance. To avoid excessive mortality or extirpation of leopard frogs during regularly scheduled tank maintenance activities (including deliberate drying of a tank prior to maintenance), a land manager should commit to the following, as appropriate: 1) subject to available funding, construct a double tank system, a small refugia site, or a fence; <u>or</u> 2) where practicable, implement tank maintenance regimes, schedules, or techniques that maintain a portion of the tank as escape cover for resident frogs during maintenance activities; <u>and</u> 3) allow all equipment used for stock tank maintenance to dry thoroughly or sterilize equipment before moving to another site to prevent disease transmission; <u>and</u> 4) grant permission to appropriate (e.g., USFWS, State Game and Fish Departments, or designated agent) qualified personnel to collect and hold leopard frogs from the tank during maintenance activities and to return the frogs to the tank upon completion of maintenance activities, and, in this event, to provide 30 days notice to such personnel prior to commencement of maintenance operations. In addition, all tank maintenance activities should be conducted during the period when leopard frogs are most active (April 1 to October 31), <u>unless</u> otherwise recommended by qualified technical advisors. If, however, none of the above measures are desired or feasible for a given stock tank, then leopard frogs should be translocated into such a tank only if it meets short-term habitat goals. If the above measures cannot be implemented, the Recovery Team or its local working group should be consulted regarding how, or whether, to proceed.

(ii) Conduct emergency stock maintenance. From time to time it may be necessary for a land manager to undertake immediate repair or maintenance actions at a stock tank in emergency situations (e.g., a flood event in which a tank is in danger of washing out). In such cases, the land manager should proceed with corrective actions as soon as possible, once any needed approvals are obtained. On non-Federal lands, the land owner/manager will be protected from Section 9 “take” violations by the “4d” special rule for the frog; thus no permits or approvals are needed from the USFWS for emergency (or any other type of) tank maintenance. On Federal lands, we recommend that the Federal land

management agency obtain authorization for take incidental to emergency tank maintenance via section 7 consultation conducted prior to the need for the action, or in emergency consultation during or after the maintenance work, if such action qualifies as an "emergency" under the consultation regulations. In any case, we recommend that the land manager report the circumstances of the action to the USFWS and appropriate State agency as soon as possible after the situation triggering the action has ended or been controlled. For purposes of this paragraph, an emergency situation is defined as any in which, in the sole judgment of the participating land manager, a stock tank is in imminent danger of destruction or significant damage as a result of emergency or urgent conditions.

(B) Livestock grazing in and around stock tanks supporting leopard frogs should be managed so as to avoid destruction or excessive deterioration of leopard frog habitat. This includes: 1) subject to available funding and approval by the participating land manager, fencing of portions of tanks that allows both access for cattle and places where frogs and their habitat will be undisturbed by cattle; 2) avoidance of excessive trampling, especially during frog breeding periods when egg masses are easily destroyed; and 3) appropriate management of the numbers and seasonality of livestock use to avoid excessive sedimentation, erosion, or degradation of water quality.

(C) The introduction of non-native aquatic predators into leopard frog habitat should be prevented or otherwise minimized and controlled via the following measures: 1) land managers should not engage in releases of American bullfrogs, non-native predatory fish, crayfish, or tiger salamanders into leopard frog habitats, and not knowingly permit any other person or organization to engage in such releases; 2) land managers should report any observed occurrences of such species in leopard frog habitats to USFWS, or other program cooperators; 3) land managers should permit access to their lands by appropriate qualified personnel, such as State of Federal biologists, necessary to implement control programs for these species (subject to advance notice); and 4) where appropriate, subject to the approval of the land manager, control measures may be conducted (e.g., temporarily drying out stock tanks that support such species).

(D) Prescribed fire, herbicide treatments, and other land treatments that alter vegetation or change runoff characteristics can have a detrimental effect on aquatic sites through the introduction of ash, sediment, herbicides, and other contaminates into the aquatic environment. While these activities may have a long-term beneficial effect for the aquatic habitat, the short-term effects could result in loss of populations in primary and secondary sites. To prevent loss of populations in this manner, any land treatment upstream of a recovery project site should include measures such as buffers around drainages, erosion control structures, and buffers around the enrolled sites to minimize possible effects, as applicable. Land managers should work with the USFWS, State agencies, or other qualified individuals to develop effective minimization measures on a case-by-case basis, where applicable (see Appendix I for additional recommendations).

Conservation Enhancement Measures

A key component of this plan is the reestablishment of frogs into suitable habitats. Each site considered for leopard frog reestablishment or translocation will present unique considerations

and challenges. A key consideration will be what, if any, improvements to the aquatic site's structure, design, depth, size, or other features will be implemented to improve leopard frog habitat quality and reliability and to achieve the plan's biological objectives. This section presents conservation enhancements that may be considered in determining what specific measures will be implemented at a given site. These enhancements can be considered on a case-by-case basis. If the land or water manager agrees to implement one or more of these enhancements, cost will be a key consideration, and full or partial funding assistance to the land manager from this plan's funding mechanisms will likely be necessary in implementing many of these measures (see "State and Federal Programs to Assist Landowners and Managers in Recovery Plan Implementation" at the end of this Participation Plan). Specific enhancements may include:

(A) *Leopard frog establishment*. Leopard frog populations may be established at appropriate sites. Existing leopard frog populations at primary sites may also be augmented if necessary to meet the biological goals for metapopulation management. See Reestablishment and Distribution Criteria above and Appendix D regarding selection of sites for population establishment.

(B) Construction of a double tank system. A double tank system is ideal for a leopard frog population site. In this configuration, one tank serves as a sediment trap and the other as the primary water reservoir. The advantage of this system is that most often during tank maintenance activities the sediment trap is cleaned out (via bulldozing, dredging, or other means) while the reservoir tank remains relatively undisturbed. The reservoir tank consequently functions as a refugium for resident leopard frogs during tank maintenance, reducing the incidental killing or injuring of frogs that might otherwise occur during sediment clearing activities.

(C) Construction of small refugia sites at single tank systems. This is a potential alternative to a double tank system. In this configuration, a small refugium, consisting of a second aquatic site, is provided or constructed near or adjacent to the primary tank. The refugium can consist of a steel or concrete tank or "drinker," wetted pasture, or natural feature (e.g., a scour basin in a nearby drainage) fed by a well, spring, or storage tank. The refugium provides cover to which frogs can escape during maintenance activities at the primary tank or can be used as a holding area to which frogs can be temporarily moved. However, any non-earthen (i.e., steel or concrete) tank system intended to support leopard frogs must include design features allowing for ingress and egress by the frogs, and, at the same time, must prevent entrapment and drowning of other animals.

(D) Fencing. Fencing is a suitable option at any tank configuration or natural aquatic site. The purpose of fencing is to prevent destruction or excessive deterioration or trampling of leopard frog habitat at an aquatic site. This can be accomplished by fencing an aquatic site in its entirety (if not needed as a stock or wildlife water source) or fencing only a portion of a site. The fenced portion provides relatively undisturbed aquatic habitat and escape cover during maintenance activities and livestock use.

(E) Deepening the tank. Tank deepening can increase the amount of water in a tank, ensuring that the tank will retain water longer during periods of dry weather or drought. It creates more permanent leopard frog habitat and can be used to upgrade a secondary population site into a primary population site. However, too deep a tank may be difficult to dry out for maintenance purposes or to rid the tank of American bullfrogs (e.g., if the tank is close to the limits of American bullfrog dispersal). Thus, tank deepening should balance the needs of relative water permanence with the ability to deliberately manipulate water levels in the tank.

(F) Well drilling. Well drilling is an ideal means to create a permanent and reliable stock water source for livestock and frogs, and any type of stock tank can be fed by a well. However, drilling and maintaining a well can be expensive and should be used only in circumstances that are technically and financially feasible.

(G) Pipelines. Pipelines can be used to connect stock tank sites (primary or secondary) to a water source. Pipelines can be constructed of a variety of materials, in a variety of configurations (e.g., buried or laid on the ground), and can be used to improve water reliability at existing tank sites or to feed new tanks. However, pipelines raise several technical considerations (e.g., topography, distance traveled) and should be used only when technically and financially feasible.

(H) Removal of aquatic predators from otherwise suitable sites. In some cases, otherwise suitable aquatic sites in the area may already contain American bullfrog populations or populations of other predatory species. Such sites could be converted to leopard frog population sites if the non-natives can be eliminated. While this strategy will depend on the feasibility of removing the exotics (e.g., on the type of species involved, the size of the water source, etc.), it should be considered at selected sites. See narrative for recovery action 1.2.9 for techniques to eliminate non-natives.

(I) Maintenance of existing habitat conditions. In some situations, a commitment to maintain existing conditions may provide a net conservation benefit to the frog. This option is useful when future threats are predictable and probable. Preventing the future diversion of water from suitable sites or maintaining seral stage of a pond or wetland by removing encroaching climax or invasive vegetation may be appropriate.

(J) Enhancement of travel corridors. Travel corridors along drainage lines and across upland areas are of particular importance in maintaining metapopulations. In areas where these corridors may be extremely long or subject to disturbances, it may be beneficial to enhance the aquatic and terrestrial habitat within these corridors. Shallow depressions that catch rainwater and provide temporary aquatic sites between primary and secondary sites would facilitate unencumbered movement within a metapopulation. In addition, fencing or road closures (seasonal or permanent) and rehabilitation of disturbed areas would also facilitate movement. Such enhancements should not overly benefit or promote dispersal of non-native predators, such as American bullfrogs.

(K) Enhancement of stream and cienega habitats. In some areas natural streams, perennial and intermittent, and cienegas will exist on a land manager's property. Enhancement of theses areas through options similar to paragraphs B, C, E, F, G, and or I, discussed above, would also be beneficial. Improvements to correct incised channels would also be beneficial for leopard frogs.

(L) Vegetation enhancement. Enhancement of riparian vegetation would be beneficial in existing and new habitats. This may include vegetation to stabilize shorelines and banks or emergent and submerged vegetation to provide aquatic habitat structure and cover for Chiricahua leopard frogs.

III. UNIQUE CIRCUMSTANCES AND OPPORTUNITIES FOR RECOVERY

Southeastern Arizona/Southwestern New Mexico and Adjacent Portions of Sonora and Chihuahua: Recovery Units 1-4. *Prepared by the Southeastern Arizona/Southwestern New Mexico Stakeholders Subgroup.*

The southern region of the Chiricahua leopard frog's range was delineated into RUs 1-4 in southeastern Arizona, southwestern New Mexico, northeastern Sonora, and northwestern Chihuahua. The land ownership and jurisdictions, considerable previous conservation efforts for the frog, and threats, particularly non-native predators, present unique opportunities and challenges for recovery of the Chiricahua leopard frog. The best model for leopard frog recovery exists on the eastern slopes of the Huachuca Mountains in RU 2, where the Ramsey Canyon leopard frog Conservation Team has been working since 1995 to protect, create and enhance habitat, and reestablish frogs. Much can be learned from the successes and pitfalls encountered during that effort. Factors that resulted in success, such as at Beatty's Guest Ranch, need to be replicated across RUs 1-4. Failures, such as the extirpation of the species from its type locality in Ramsey Canyon, also need to be evaluated so that we may avoid population losses elsewhere. Anna and Matt Magoffin, in the Malpai Borderlands of RU 3, have successfully maintained Chiricahua leopard frogs at their ranch east of Douglas. The Magoffin Ranch is a model for coexistence of working ranches and frogs.

The Malpai Borderlands Group in RU 3 has recently signed a Safe Harbor Agreement for the Chiricahua leopard frog that will remove liabilities concerning ESA section 9 take violations of the frog for ranchers interesting in contributing to frog recovery. The "Actions Available for Leopard Frog Recovery" have been adapted from that agreement. Now that the agreement is in place, discussions should be initiated with interested and willing ranchers to reestablish frogs in the Malpai Borderlands. Discussions are also underway with the Altar Valley Alliance in RU 1 concerning potential Safe Harbor Agreements and Habitat Conservation Planning that could facilitate recovery of the frog. In 2004, Ross Humphreys agreed to the establishment of a Chiricahua leopard frog refugium on one of his ranches in the Altar Valley.

Much of the lands in RUs 1-4, and thus much of the potential for recovery, is managed by the Douglas, Sierra Vista, and Nogales Ranger Districts of the Coronado National Forest. The BLM also has important recovery lands at Las Cienegas-Empire Ranch. A successful recovery effort

for the frog in these RUs will not occur without an aggressive effort on these public lands to protect extant populations and establish new populations in suitable habitats. Work by Phil Rosen and Cecil Schwalbe in the Altar Valley in RU 1, as well as the San Bernardino Valley in RU 3, developed the methods for eliminating vertebrate non-native predators from simple aquatic systems. These methods will need to be applied across the RUs on both public lands and the lands of willing, cooperative private landowners.

The borderlands have in recent years experienced a dramatic increase in smuggling, illegal immigration, and associated law enforcement by U.S. Border Patrol and others. These activities complicate recovery activities and make working in the borderlands potentially dangerous. We will need to coordinate our activities with the Border Patrol and other law enforcement agencies to ensure the safety of those engaged in field recovery projects and to minimize damage to recovery projects from border activities.

Significant portions of RUs 1-4 lie south of the international boundary in Sonora and Chihuahua. Little is known about extant populations, threats, and recovery needs and opportunities in Mexico. We will need to forge partnerships with IMADES, the Ajos-Bavispe Forest Reserve and Wildlife Refuge, non-governmental conservation groups, ejidatarios, and ranchers. Members of the Malpai Borderlands Group own ranches in the Sierra San Luis complex and would be good contacts to foster. Basic information about the frog and its recovery needs should be collected first, followed by development of cooperative recovery projects with willing partners.

Finally, we expect that significant funding for on-the-ground projects will materialize only if the recovery team and its partners actively seek grants. We strongly endorse the recommendations from the PHVA report to establish a funding coordinator within regional recovery working groups. Little progress towards recovery will be made unless new sources of funding can be tapped.

Mogollon Rim Region, Arizona: Recovery Unit 5, and Arizona portions of Recovery Units 6 and 7. *Prepared by the Mogollon Rim Stakeholders Subgroup.*

This section of the Participation Plan is prepared to document recommendations by the Mogollon Rim Stakeholders Subgroup (MRSS) to the USFWS. These recommendations, which are memorialized here in Appendix A, include methods of implementing actions to recover the Chiricahua leopard frog that will meet the goal, strategy elements, and recovery criteria of the Recovery Plan, while providing a framework to integrate recovery actions within existing social and economic conditions.

Existing conditions, including physical (e.g., watersheds), biological (e.g., distribution of the species, habitats, threats), social/political and economic (e.g., governmental, non-governmental, and tribal aspects) in MRSS area provide a context in which recovery actions will be implemented. Information about these topics, specific to the Mogollon Rim area of Arizona, can be found in the RU descriptions for RU 5, 6, and 7 in the “RUs” portion of the recovery plan and in Appendix B.

RUs 5, 6, and 7 in Arizona are managed primarily by the U.S. Forest Service (Coconino, Tonto, and Apache-Sitgreaves National Forests) and by the White Mountain and San Carlos Apache Tribes. Recovery opportunities and challenges differ among these jurisdictions. We will begin with a discussion of the National Forest lands.

National Forests

Prompt and successful implementation of recovery actions on National Forest lands will be critical to recovering the frog in RUs 5-7 in Arizona. The only known extant populations and all of the MAs are on Forest lands. As a Federal agency, the Forest Service has a mandate under section 7(a)(1) of the ESA to use its authorities to carry out programs for the conservation of listed species. Furthermore, the National Forest Management Act of 1976 requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each Forest. Among other things, these Forest plans must provide for wildlife and fish, and a diversity of plant and animal communities, which include Chiricahua leopard frogs. The Forests are beginning the process of revising their Forest Plans. As a result, there is an opportunity to inject recovery strategies and actions into these planning efforts.

Compared to RUs 1-4, the RUs on the Mogollon Rim, particularly RU 6, appear to have considerable aquatic habitat for potential reestablishment of Chiricahua leopard frogs. However, many of these waters are overrun with crayfish or other non-native predators, while at other sites frogs disappeared for unknown reasons. At these latter sites, we do not know if the factors that caused the extirpations are still in operation. If a site appears suitable for frogs, experimental reestablishment projects will be necessary to determine whether the site can support a population. Many of these efforts will likely fail, but through monitoring we should be able to learn from our failures and develop insight as to why frogs disappeared in the first place.

We expect that support and funding for Chiricahua leopard frog recovery will be difficult to obtain for at least the next several years. However, as indicated in the PHVA summary report in section III of this Appendix, if grassroots, local support can be built among a variety of stakeholders, we believe administrative and political barriers will lessen and funding will become easier to obtain. We strongly recommend implementation of broad-based community planning, as described in section III, to build these coalitions. Because RUs 6 and 7 extend into New Mexico, coordination with working and planning groups there will be important to developing comprehensive recovery strategies. A funding coordinator or committee within local recovery working groups should be assigned to pursue grants and other funding opportunities.

Working with the San Carlos Apache and White Mountain Apache Tribes

Secretarial Order 3206 clarifies the responsibilities of Department of the Interior agencies (including USFWS), and acknowledges treaty obligations and government-to-government relations necessary when dealing with Native American Tribes and Tribal trust resources. During recovery planning, Interior is directed to cooperate with affected Tribes to develop and implement recovery plans in a manner that minimizes the social, cultural, and economic impacts on Tribal communities, consistent with the timely recovery of listed species. Interior agencies

are further directed to assist Tribes in developing and expanding Tribal programs that promote the health of ecosystems upon which sensitive species (including listed species) depend.

Consistent with the Secretarial Order, USFWS should develop Memoranda of Understanding with the Tribes that identify recovery opportunities, research and monitoring needs, and funding necessary to carry out these needs and opportunities. Cooperative projects and opportunities are also possible with the Forest Service and BLM, where their lands border Tribal lands. Information about recovery projects, monitoring data, and localities of frogs or other sensitive resources are Tribal trust resources and would not be distributed outside of the Tribes, unless authorized by the Tribes. The San Carlos Apache and White Mountain Apache Tribes contain many historical localities for Chiricahua leopard frogs and may contain extant populations and potential establishment or re-establishment sites. Considerable opportunity exists to work cooperatively with the San Carlos Apache and White Mountain Apache Tribes to achieve recovery in the Mogollon Rim region.

San Carlos Apache Tribe

The San Carlos Apache Reservation consists of 1.8 million acres in eastern Arizona. Both the San Carlos Apache Tribe and the U.S. Government have mutually agreed-upon responsibilities relating to fish, wildlife, and recreational resources that are important to the sustenance, cultural enrichment, and economic support of the Apache people. The goal of the San Carlos Apache Tribe is two-fold: 1) to fulfill and execute their role as environmental co-managers with the U.S. Government, and 2) to promote the conservation, development and utilization of these resources for the maximum benefit of the San Carlos Apache people, both now and in the future. In order to properly inventory, conserve, develop, and use wildlife and related unique natural resources for the benefit of its tribal members, the San Carlos Apache Tribe has established a Recreation and Wildlife Department. The Recreation and Wildlife Department provides biological expertise, administrative support, and law enforcement to protect and enhance natural resources on reservation lands. These natural resources include fauna, flora, and scenic, historical, or other resources, but do not include resources that are an integral part of a farm or ranch unit. The Recreation and Wildlife Department also supports the development of special interests resources for leisure time activities, such as birding, fishing, hunting, and hiking.

As part of its overall recovery plan, the San Carlos Recreation and Wildlife Department started implementing surveys to locate Chiricahua leopard frogs on the Reservation in 2004. Currently, the Department is in the first stages of developing a database for the leopard frogs.

The database will be significant, as there are over 350 stock tanks, seven perennial streams, and five reservoirs on the reservation. The goal of the Recreation and Wildlife Department is to implement water development projects on the reservation to improve stock tanks, springs, and windmills for both wildlife and fish species and to sustain water throughout the year and during drought times. In addition to such water development projects, the Tribe will be implementing a guideline or protocol for maintenance on stock tanks. This will help save and protect the Chiricahua leopard frog habitat if they inhabit a stock tank before renovations start. The frogs can be collected and moved to a new location or a new water resource can be added for cattle. Habitat for the Chiricahua leopard frog can be easily modified along with these projects to

protect the species, however, Memoranda of Understanding and Tribal approval will need to be in place before recovery efforts, research, and monitoring can take place.

West-Central New Mexico Region: Recovery Unit 8 and New Mexico portions of Recovery Units 6 and 7. *Prepared by the West-Central New Mexico Stakeholders Subgroup.*

Many of the actions discussed in Section IV of this plan to support the Recovery Plan's strategy of protecting existing populations of leopard frogs, developing metapopulations of leopard frogs, and establishing isolated refugia populations of leopard frogs will apply across the West-Central New Mexico range of the frog. However, as the range of leopard frogs is diverse and subject to substantially varied threats and opportunities, unique circumstances and opportunities in each of the RUs that include portions of West-Central New Mexico are discussed below.

RU 6 includes the Mogollon Rim within the Gila National Forest and the Tularosa, San Francisco, and Upper Gila drainages. RU 7 includes the Big Burro Mountains and the mainstem of the Gila River. RU 8 includes the eastern portion of the Black Range and the drainages leading into the Rio Grande. RUs 6 and 7 extend into Arizona. Detailed information about environmental setting, frog habitats and localities, threats, recovery needs, land management, and land-use history can be found in the RU descriptions in "Recovery Units" in the body of the recovery plan, and in Appendix B.

In West-Central New Mexico, the primary threats to leopard frogs are predation by non-native species and the rapid spread of infectious disease. Introduced predaceous fishes, American bullfrogs, and crayfish are the primary species responsible for the local decline in leopard frog populations. A fungal skin disease, chytridiomycosis, has been linked to amphibian decline in many parts of the world, including the Chiricahua leopard frog in Arizona and New Mexico.

A number of other factors have been identified as causes or possible causes of amphibian decline in New Mexico. Other documented threats include degradation and loss of habitat as a result of water diversions and groundwater pumping; improper livestock management; a history of fire suppression and grazing that has increased the likelihood of crown fires; mining, development, and environmental contamination; disruption of metapopulation dynamics; and the increased probability of extirpation or extinction resulting from small numbers of populations and the dynamic nature of frog habitats. These threats are described in detail in Part 1 of the recovery plan, and by RU in Appendix B.

The majority of the lands and significant recovery potential in RUs 6-8 in New Mexico are on the Gila National Forest. As discussed above by the Mogollon Rim Stakeholders, National Forests have mandates under the ESA and the National Forest Management Act to provide for fish and wildlife and to use their authorities to protect and recover threatened and endangered species. The Gila National Forest is beginning the process of revising its 1986 Forest Plan. This planning effort is an opportunity to build frog recovery efforts into what will guide forest management for years to come.

Considerable opportunities also exist for recovery on private lands. Ongoing survey, research, and recovery work on the Chiricahua leopard frog at Ted Turner's Ladder Ranch in RU 8 is a

model for how we may be able to work with other willing private landowners and ranchers in West-Central New Mexico. Randy Jennings has also successfully worked with The Nature Conservancy on the Mimbres River, and with Phelps Dodge on their Chino Mines properties near Hurley in RU 8. These successful coalitions should be further developed and advertised as examples of how private individuals, organizations, and corporations can work together to protect a threatened species. These examples may encourage others to participate in the recovery process.

Chytridiomycosis appears to be especially virulent in West-Central New Mexico. Unlike some populations in southeastern Arizona that have persisted for several or many years with the disease, chytrids typically wipe out populations in short order in West-Central New Mexico. As a result, taking steps to minimize the risk of disease transmission (see Appendix G) is particularly important. Warm springs are environments in which frogs are most likely to survive chytrid outbreaks, thus protection of these sites and their frog populations is also of heightened importance.

IV. PROGRAMS TO ASSIST LANDOWNERS AND MANAGERS IN RECOVERY PLAN IMPLEMENTATION

STATE PROGRAMS

Arizona Game and Fish Department

Stewardship Program

This program provides technical management assistance, including use of heavy equipment, materials, and labor; or reimbursement of materials and labor, to enhance wildlife habitat and populations. Projects can occur on private or public lands. Contact AGFD's Regional Habitat Programs, Flagstaff (928/774-5045), Mesa (480/981-9400), Pinetop (928/367-4281), or Tucson (520/628-5376).

Landowner Incentive Program (LIP)

This program provides funds for on-the-ground activities that enhance habitats or provide other conservation benefits for "at risk" species on private lands. LIP is a grant program establishing a partnership among Federal/State governments and private landowners. At the Federal level, administrative oversight will be provided by the USFWS. The USFWS will award grants to states for programs that enhance, protect, and/or restore habitats that benefit federally listed species, proposed or candidate species, or other species at risk on private lands. The State role in the implementation of LIP is to provide technical and financial assistance to private landowners for projects that meet the aforementioned criteria. The private landowner role is to provide the habitat necessary to accomplish the objectives of LIP. Additionally, the USFWS will also require a 25 percent non-Federal cash match or in-kind contribution to be eligible for these funds. For information, contact: Landowner Relations Program Manager, 2221 W. Greenway Rd., Phoenix,

AZ 85023-4312, or one of AGFD's Regional Habitat Programs in Flagstaff (928/774-5045), Mesa (480/981-9400), Pinetop (928/367-4281), or Tucson (520/628-5376).

Heritage Grants Program

AGFD's IIAPM (Identification, Inventory, Acquisition, Protection and Management of Sensitive Habitats) sub-program provides funds through a competitive process for projects that will preserve and enhance Arizona's natural biological diversity. The funding focus is directed annually toward species and habitat objectives that will give the greatest return for the Heritage funds invested. Contact the Heritage Grants Coordinator (602/789-3530).

Arizona Department of Water Resources

The Arizona Water Protection Fund Commission

All applicants will be required to demonstrate the direct benefit(s) to rivers, streams and/or riparian habits in their proposals. Complete information regarding the grant cycle, including workshop times is posted on the Arizona Water Protection Fund website: www.awpf.state.az.us. If you cannot access the web site and would like information mailed to you, contact the Arizona Water Protection Fund office at (602) 417-2400, ext. 7016.

FEDERAL PROGRAMS

U.S. Fish and Wildlife Service

North American Wetlands Conservation Act

This program is designed primarily to implement the North American Waterfowl Management Plan, but may have some application for Chiricahua leopard frog recovery plan implementation. Proposals are 4-year plans of action supported by an Act grant and partner funds to conserve wetlands and wetland-dependent fish and wildlife through acquisition (including easements), enhancement, restoration, and other eligible activities. Grants may be used to enhance or restore habitats on private, State, or Federal lands. A 1:1 non-Federal match is required. Contact Coordinator, North American Wetlands Conservation Council, USFWS, 4401 North Fairfax Drive, Room 110, Arlington, Virginia 22203 (703/358-1784, fax: 703/358-2282). Electronic mail address is r9arw_nawwo@mail.fws.gov; the internet address is http://birdhabitat.fws.gov.

Partners for Fish and Wildlife Program

This program provides technical and financial assistance to landowners who want to improve fish and wildlife habitat on their property. The program is open to private individuals, tribes, counties, and State government. Contact USFWS, Phoenix (602/670-6150). Information on funding restoration projects on private land is available at: website:www:fws.gov/arizonaes/.

Endangered Species Act "Traditional" Section 6 Conservation Grants

These are funds provided to AGFD and NMDGF to implement recovery actions, survey and monitor of sensitive species, candidate assessment, and other related actions. The funds may be used on private, State, or Federal lands. In Arizona, contact the USFWS Traditional Section Coordinator (602/242-0210). Contact the AGFD Non-game Branch in Phoenix for information about reptile and amphibian Section 6 projects (602/789-3555). For projects in New Mexico, contact NMDGF (505/476-8106).

Endangered Species Act "Non-traditional" Section 6 Funds

Recent initiatives have provided additional Federal funding to AGFD and NMDGF for habitat conservation planning and land acquisitions. For information on these grants, contact: AGFD Habitat Branch (602/789-3602), NMDGF (505/476-8106), or USFWS-Albuquerque Federal Aid Endangered Species Grants Coordinator (505/248-7450). Information is also available through the USFWS website, at: http://www.fws.gov/endangered/grants/section6/index.html.

Habitat Conservation Planning Assistance Grants
These grants fund development of Habitat Conservation Plans (HCPs) through support of baseline surveys and inventories, document preparation, outreach, and similar planning activities.

HCP Land Acquisition Grants
These funds may be used to acquire land associated with approved HCPs. Grants do not fund the mitigation required by an HCP permittee, but rather support conservation actions by the State or local governments that complement mitigation.

Recovery Land Acquisitions Grants
These funds may be used for acquisition of habitat to secure long-term protection for a listed species. Land acquisition projects that address high priority recovery plan actions are most competitive.

Private Stewardship Grant Program

This program provides funds and other assistance to individuals and groups engaged in local, private, and voluntary conservation efforts that benefit Federally-listed proposed, or candidate species, or other at risk species. Contact USFWS, Arlington, Texas (817-277-1100). More information about the program is available on the USFWS website, at: http://www.fws.gov/endangered/grants/private_stewardship/index.html.

Tribal Wildlife Grants Program

This program is designed to develop and implement programs for the benefit of wildlife and their habitat, including species that are not hunted or fished. Participation is limited to federally-recognized Indian tribal governments. There is no matching requirement; however, USFWS will consider matching funds as an indication of Tribal commitment to the program and to encourage

partnerships. Matching and cost sharing requirements are discussed in 43 CFR Part 12, Section 12.64. In FY 2004, an estimated $5,926,000 was allocated to Tribes under this program. Application procedures are spelled out in the "Tribal Wildlife Grant Application Kit" available electronically at http://grants.fws.gov/tribal.html.

Tribal Landowner Incentive Program

This is a grants program for actions and activities that protect and restore habitats that benefit Federally listed, proposed, or candidate species, or other at-risk species on tribal lands. The program is available to federally recognized Tribes. Tribal landowner incentive program funds can be used for environmental review, habitat evaluation, permit review, and other compliance so long as those activities are directly related to the Tribal landowner incentive program project. A minimum of 25 percent non-Federal matching funds is required. Contact USFWS, Albuquerque, New Mexico (505/248-6810) for additional information. Also see the grant application kit at http://grants.fws.gov.

Sonoran Joint Venture Grant Program

The objective of the Sonoran Joint Venture Awards Program is to support the investigation and conservation of all birds and their habitats within SJV boundaries by providing funds through a competitive program. Proposals for projects that support the SJV mission and objectives are eligible for funding. This includes: habitat management, research, monitoring, education, community involvement, outreach, ecotourism, and training. Although the program targets birds, projects may benefit Chiricahua leopard frogs or other sensitive species, as well. Typical project awards in past years have ranged from $3,000-$25,000. See: www.sonoranjv.org.

State Wildlife Grants

The State Wildlife Grants Program provides Federal funding to every State and territory to support cost effective conservation aimed at keeping wildlife from becoming endangered. This program continues the long history of cooperation between the Federal government and the states for managing and conserving wildlife. A two-thirds or greater non-Federal match is required. State Wildlife Grants are administered by AGFD and NMDGF. For information about the program, see www.teaming.com.

Environmental Protection Agency

EPA’s website of "Catalog of Federal Funding Sources for Watershed Protection" contains a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed protection projects. Searches can be limited to those for which "conservation districts" are eligible. See http://cfpub.epa.gov/fedfund/.

Natural Resource Conservation Service

Conservation Reserve Program

This is a voluntary program that offers annual rental payments and cost-share assistance to establish long-term resource conservation. The program provides up to 50 percent of participant costs to establish target management practices on private lands, and could be used to help establish riparian buffers and cienegas on private lands. In Arizona, contact NRCS, Tucson (520/670-6602). In New Mexico, contact NRCS (505/761-4425).

Wildlife Habitat Incentives Program (WHIP)

This program provides technical assistance and cost-share (up to 75 percent) to help establish and improve fish and wildlife habitat, primarily on private lands. In Arizona, contact NRCS, Tucson (520/670-6602, ext. 226). In New Mexico, contact NRCS (505/761-4425).

Wetlands Reserve Program

This is a program that can be used to cost-share (NRCS pays up to 75 percent) restoration of privately-owned wetlands or former wetlands on rangelands or farmlands. In Arizona, contact NRCS, Tucson (520/670-6602). In New Mexico, contact NRCS (505/761-4425).

U.S. Forest Service Programs

Bring Back the Natives

This initiative is a national effort by the Bureau of Land Management and Forest Service in cooperation with the National Fish and Wildlife Foundation to restore health of entire riverine and aquatic systems and their native species. In turn, national, State, and local partners make their own matching contributions to accomplish improved habitat and water quality. Three programs are available through the Forest Service: 1) *Rise to the Future* is a program to enhance fisheries and aquatic resources, 2) *Every Species Counts* conserves sensitive flora and fauna, and helps recover endangered species, and 3) *Get Wild* targets protection and improvement of riparian and wetland habitats and associated species. Forest Service funds must be matched with labor and materials. Contact the Coronado National Forest, Sierra Vista Ranger District, 5990 S. Highway 92, Hereford, Arizona, 85615 (520/378-0311). Bring Back the Natives funds can also be obtained through the National Fish and Wildlife Foundation (see above).

National Association of Conservation Districts

Five-Star Restoration Challenge Grants to Fund Habitat Restoration Projects

The National Association of Counties, the National Fish and Wildlife Foundation, and the Wildlife Habitat Council, in cooperation with the U.S. Environmental Protection Agency, the Community-Based Restoration Program within National Oceanic and Atmospheric Administration's Fisheries Program, and other sponsors invite applications for the Five-Star Restoration Challenge Grant Program. The program provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration

projects that build diverse partnerships and foster local natural resource stewardship through education, outreach, and training activities. Projects must involve diverse partnerships of, ideally, five organizations that contribute funding, land, technical assistance, workforce support, and/or other in-kind services. For further information, see the National Fish and Wildlife Foundation website at http://nfwf.org/programs/5star-rfp.htm.

PRIVATE GRANTS AND FOUNDATIONS

Many private grants and foundations could provide funding and other resources for recovery action implementation. An annual directory, entitled "Environmental Grantmaking Foundations" contains information about 800 foundations. It is available from the Resources for Global Sustainability, Inc., P.O. Box 3665, Cary, NC 27519-3665 (phone: 800-724-1857, rgs@environmentalgrants.com). A website (Red Lodge Clearinghouse Funding Search – http://www.redlodgeclearinghouse.org/resources/search.asp) also provides an abundance of information on funding opportunities. Several examples of private grant and foundation programs are listed below:

National Fish and Wildlife Foundation Grants

See website (http://www.nfwf.org) and click on Grant Programs.

Toyota TAPESTRY Grants for Teachers

Fifty teachers will be awarded as much as $10,000 and another 20 will receive grants up to $2,500 for innovative science projects in one of three categories, including environmental science. Projects should demonstrate creativity, model a novel way of presenting science and be implemented in your school district over a one-year period. For general information, tips on applying, or examples of winning projects, visit http://www.nsta.org/programs/tapestry. To download the application or request entry materials, go to http://www.nsta.org/programs/tapestry/howtoapply.asp. For more information, e-mail tapestry@nsta.org.

Turner Endangered Species Fund

This private, non-profit charity dedicates itself to conserving biodiversity by ensuring the persistence of imperiled species and their habitats. Projects funded by Turner Endangered Species Fund are focused on carnivores, grasslands, plant-pollinator complexes, and species that historically ranged onto properties owned by Ted Turner. Contact Turner Endangered Species Fund (406/556-8500 or http://tesf.org/tesf) for more information.

V. STAKEHOLDER SUBGROUP ORGANIZATION AND PARTICIPATION PLAN PREPARATION

Stakeholders were appointed by the USFWS, and included agency representatives and the public whose interests may be affected by actions deemed necessary to recover the Chiricahua leopard

frog. Initially, 38 individuals, agencies, or organizations were invited by the Regional Director to serve as Stakeholders. These included local residents, landowners, ranchers, cattlegrowers' organizations, environmental organizations, mining companies, and representatives of County, State and Federal agencies and governments that might be affected by implementation of the recovery plan. Other possible members were suggested to USFWS at the first organizational meetings of the Stakeholders Subgroups. In all, 47 individuals accepted the invitation to serve, and were appointed to one of three Stakeholders Subgroups (see "Contacts" section of Recovery Plan). In addition, liaisons from the White Mountain Apache and San Carlos Apache tribes were invited and attended several Mogollon Rim Stakeholders meetings and Technical Subgroup meetings. A representative from IMADES in Sonora attended some of the Technical Subgroup meetings and one of the joint meetings among all subgroups. USFWS representatives acted in a support capacity and as liaisons between the Stakeholders Subgroups and the USFWS Regional Director, but were not members of the Stakeholders Subgroups. Several other individuals who were invited to serve on the team elected not to be members, but requested to remain on the mailing list for meeting announcements and meeting notes. Other persons or organizations that were invited but did not respond to the invitation were also not considered members but were

Figure A1: Mike Sredl and Kevin Wright lead a discussion at the March 30-31, 2004 joint meeting of the Technical and Stakeholders Subgroups in Silver City, New Mexico.

sent meeting announcements and notes (see "List of Contacts" section: "On the Mailing List, but not a voting member"). Only individuals who were members of one of the Stakeholders Subgroups received copies of interim draft recovery plans for review. Stakeholders Subgroups are components of Recovery Teams, and as such are exempt from the requirements of the

Federal Advisory Committee Act, which otherwise would require that Subgroup meetings be open to the public. In this case, each of the Stakeholders Subgroups elected to have meetings open to anyone who wished to attend. Non-members were sometimes invited, and others occasionally came to the meetings, but only those listed in the "List of Contacts" of the recovery plan section were regularly notified of upcoming meetings. Organization, structure, decision-making rules, and other process rules were determined by the Subgroups. The objective was to establish procedural rules that were fair and that would result in decisions and products representative of the diverse makeup of each Subgroup. A Terms of Reference was distributed for review and comment to all of the subgroups at the first meetings. This document was intended to clearly spell out rules of order for the recovery team; each subgroup member would then sign the Terms of Reference, which would also be signed by the USFWS Regional Director. There were some questions and suggested changes to the Terms of Reference from both the Technical and Stakeholders Subgroups. Progress on finalizing and signing the document stalled and the Stakeholders moved on to development of this Participation Plan and other tasks. In the end, the Subgroups operated well, despite the absence of a Terms of Reference.

A team leader or mediator was initially elected by each Subgroup (Terry Myers: Mogollon Rim, Anna Magoffin: Southeastern Arizona, and Ben Brown: New Mexico) who ran the meetings. Cecelia Overby and Ron Bemis took over as Team Leaders for the Mogollon Rim and Southeastern Arizona/Southwestern New Mexico Subgroups, respectively, during 2004. The Subgroups also identified liaisons with other Stakeholders and the Technical Subgroup (see Contacts section). A Subgroup member or individual from the USFWS prepared draft meeting notes for the team leader or mediator. After review, these notes were sent to Subgroup members. The content of notes were reviewed for accuracy and either adopted, or revised and adopted, at the following meeting. The Subgroups made decisions by "facilitated consensus", in which the members present would talk through an issue and try to come to consensus. If consensus could not be reached, a majority vote of members present would decide the issue. Any member not agreeing with a decision could write a dissenting view, which would become part of the decision-making record.

The Subgroups met on the following dates: Southeastern Arizona/Southwestern New Mexico: 19 November 2003, 13 January 2004, and 5-6 August 2004; West-Central New Mexico (includes meetings before and after the southwestern portion of New Mexico joined with the Southeastern Arizona Subgroup in 2004): 18 November 2003, 23 October 2004; and Mogollon Rim: 15 January 2004, 4 March 2004, 7 June 2004, and 21-22 July 2004. Representatives from all the subgroups met with Technical Subgroup members in joint recovery team meetings during 30-31 March (Figure A3) and 9-10 September 2004, and then again at the PHVA workshop during 6-9 December 2004.

VI. CONTACTS

If a private landowner wants to help with the recovery effort, needs information on programs that provide assistance for recovery actions, or has questions about regulatory liability or other topics, who should they contact? Initial contacts should probably be with other landowners or biologists or resource specialists in your area. Each RU, MA, or region will have working groups, which

may be the Stakeholders Subgroups or extensions thereof. Contacts provided in the "List of Contacts" (pg. 132) in the body of the recovery plan are a good start. Any of these people should be able to either provide the information you need or direct you to it.

VII. CONCLUSION

The recovery plan, especially the Implementation Schedule, as discussed above, presents a wide array of activities, significant expenditure of funds, and long-term commitments by participating individuals and organizations. For recovery and eventual removal of the Chiricahua leopard frog from the protections of the ESA to occur, these actions must achieve on-the-ground results. They must also be realistic and flexible. Cost for the most part will be borne by the State and Federal wildlife management agencies and public land managing agencies, as well as from grants and foundations, in conjunction with willing private land cooperators. Private property and water rights will be respected. On public lands, activities shown in the Implementation Schedule must also complement the social and economic setting of each region, while achieving the needed biological results. Cooperation among all interested parties must be stressed at all times. While the recovery plan focuses on the Chiricahua leopard frog, it should be an integral component of the many efforts in the Southwest to maintain the health of human residents and the array of wildlife and plants. For the recovery plan to succeed, a cooperative effort that considers the diverse values and uses of the area must be forged among the many involved and affected private and public interests.

APPENDIX B

Recovery Unit Descriptions

Descriptions of the environmental setting, land uses and management, threats, frog populations, MAs, and other aspects of each of the eight RUs are detailed below. Additional information about the units can be found in the body of the recovery plan in the "Recovery Units" section.

Threats to the recovery of the frog are described in narrative fashion, but also in a tabular threats assessment in each RU description. The tabular assessments were derived from the threats analyses in The Nature Conservancy's "The Five-S Framework for Site Conservation: A Practitioner's Handbook for Site Conservation Planning". Herein, we have extracted that portion of the Handbook and associated Excel spreadsheet that tabulates and quantifies stresses to a conservation target (in this case the Chiricahua leopard frog) and underlying sources of threats. Stresses alter or impair ecological attributes that reduce the viability of the Chiricahua leopard frog. Sources of stress represent the proximate cause of the stress. For example, chytridiomycosis (a source of stress) causes disease (the stress), and American bullfrog predation (a source of stress) is a form of extraordinary predation (the stress). Each stress has at least one, and often multiple sources. The same set of six stresses was employed across RUs; however, the sources of stress varied depending on the circumstances and conditions in each RU.

Each stress is ranked in terms of its severity (level of damage to the frog that can reasonably be expected within 10 years under current circumstances) and scope (the geographic scope of the stress within the RU). Stress and scope are ranked in the following categories:

<u>Severity</u>

Very High The stress is likely to eliminate the frog over some portion of its occurrence in the RU.

High The stress is likely to seriously degrade the viability of the frog over some portion of its occurrence in the RU.

Medium The stress is likely to moderately degrade the viability of the frog over some portion of its occurrence in the RU.

Low The stress is likely to only slightly impair the viability of the frog over some portion of its occurrence in the RU.

<u>Scope</u>

Very High The stress is likely to be very widespread or pervasive in its scope, and affect the frog throughout its occurrence in the RU.

High The stress is likely to be widespread in its scope, and affect the frog at many of the frog's locations in the RU.

Medium The stress is likely to be localized in its scope, and affect the frog at some of the frog's locations in the RU.

Low The stress is likely to be very localized in its scope, and affect the frog at a limited number of the frog's locations in the RU.

For each source of stress, its contribution, acting alone, to the full expression of a stress under current circumstances, and its irreversibility, are also quantified. Contribution and irreversibility are ranked as follows:

Contribution

Very High The source is a very large contributor of the particular stress.

High The source is a large contributor of the particular stress.

Medium The source is a moderate contributor of the particular stress.

Low The source is a low contributor of the particular stress.

Irreversibility

Very High The source produces a stress that is not reversible (e.g. wetland converted to a shopping center).

High The source produces a stress that is reversible, but not practically affordable.

Medium The source produces a stress that is reversible with a reasonable commitment of resources.

Low The source produces a stress that is easily reversible at relatively low cost.

We portray the results of the threats assessment for each RU in the descriptions that follow. Two Tables are included for each RU, the first of which is a viability summary (e.g., Table B1). The viability summaries list each of the six stresses identified by the recovery team with its corresponding scope and severity. An overall ranking for each stress is calculated from scope and severity, and is listed in the right column of the table.

The second Table lists and ranks sources of stress, contribution, and irreversibility (e.g., Table B2). Contribution and irreversibility are averaged to produce a rank for the source ("Source" row under each source of threat). That rank for the source is combined with the stress rank to produce a combined rank ("Combined" row), or "threat" rank. A "threat to system" ranking is then calculated for all "threats" associated with a particular source of stress (e.g. see right

column in Table B2). It summarizes the individual threat ranks (combined ranks) in each stress column. The threat to system rank is at least the highest rank given to any particular source of stress. For instance, if any of the combined ranks were Very High, the threat to system rank would also be Very High. If there are multiple threats related to the same source of stress, the threat to system rank may be adjusted upwards using the "3-5-7" rule:

Three High rankings equal a Very High.
Five Medium rankings equal a High.
Seven low rankings equal a Medium.

The spreadsheet has additional algorithms for different combinations of rankings. For more information about the process and the algorithms that produce the summary statistics, see The Nature Conservancy's "The Five-S Framework for Site Conservation: A Practitioner's Handbook for Site Conservation Planning".

Threat assessments were conducted by subsets of the Technical and Stakeholders Subgroups. The Mogollon Rim Stakeholders met with a few Technical members to develop and rank stresses and sources and stresses in a meeting on 20-21 July 2004. Threats assessments for RUs 5 and 6 were completed. A subset of the Stakeholders met later to conduct a threats assessment for the Arizona portion of RU 7. At a 5-6 August 2004 meeting, the Southeastern Arizona Stakeholders and some Technical Subgroup members conducted threats assessments for RUs 1-4. Earlier in the year, several New Mexico Stakeholders and Technical Subgroup members conducted threats assessments for the New Mexico portions of RUs 3, 6, 7, and 8. To standardize stresses across RUs, the New Mexico members reevaluated the New Mexico RUs using the set of stresses developed in Arizona. We then merged the Arizona and New Mexico assessments for RUs 3, 6, and 7, which cross state lines.

The purpose of the threats assessment was to summarize threats to the Chiricahua leopard frog in a way that was comparable across RUs and that provided some quantification of those threats. The "quantification" portrayed by the tables are actually best guesses, but they are derived from consensus among technical and stakeholder experts in land uses and management, non-native species, distribution and habitat use of Chiricahua leopard frogs, and other aspects of the conservation biology of this species. The assessments provide the basis for RU-specific threat abatement, and channeling of resources to address the most significant threats in each RU. Assessment of threats at specific recovery sites should be based on a site-specific analysis within the context of this broader threats assessment (see recovery actions 2.1 and 2.2).

RECOVERY UNIT 1: TUMACACORI-ATASCOSA-PAJARITO

Environmental Setting

Recovery unit 1 includes basin and range topography in the western extreme of the Chiricahua leopard frog's range in Santa Cruz and Pima Counties, Arizona, and adjacent portions of Sonora. Elevations range from about 3,200 to 6,249 feet at Atascosa Lookout. Prominent valleys in Arizona include the Santa Cruz River Valley on the east and the Altar Valley on the west. From west to east in Arizona, the RU includes the Baboquivari/Pozo Verde, San Luis, Las Guijatas, Pajarito, southern edge of the Sierrita, Atascosa, and Tumacacori mountains. In Sonora, RU 1 includes the Rio Bambuto Valley on the east, and the mountains of the Sierra Cibuta, which are a southward extension of the Pajarito/Atascosa Mountain complex. Most drainages in Arizona flow northward to the Santa Cruz/Gila drainage, while the Sonoran portions drain primarily into the Rios Bambuto, Altar, and Seco, and then into the Rio Magdalena.

Vegetation communities include Madrean evergreen woodlands in the higher mountains, and semi-desert grasslands in the Altar, Santa Cruz, and Rio Bambuto valleys. Semi-desert grasslands are also found on the western edge of the Sierra Cibuta (Brown and Lowe 1980). Shrub, tree, and cacti invasion has occurred throughout the semi-desert grasslands, in some cases to the extent that these areas are floristically closer to the Arizona upland subdivision of Sonoran Desert scrub than to grasslands.

Significant human population and development are mostly peripheral to the RU in Nogales, Arizona and Sonora. The latter has a population of approximately 200,000, while about 21,000 reside in Arizona's Nogales. Agriculture and development also occurs along the Santa Cruz River Valley, again, mostly peripheral to the RU. The town of Arivaca, located in the western portion of the RU, has a population of about 900. Numerous small communities occur in the Sonoran portion, including Las Borregas, El Alamito, Sane, and Sasabe, among others.

Chiricahua Leopard Frog Populations

Chiricahua leopard frogs are currently and historically well-represented in the Arizona portion of the RU (Clarkson and Rorabaugh 1989, Hale 1992, Suhre *et al.* 2004). Sycamore Canyon and associated stock tanks within dispersal distance in the Pajarito and Atascosa mountains form a metapopulation. Additional populations occur in the Altar Valley on the Buenos Aires NWR and adjacent portions of the Coronado National Forest. A refugium population of Altar Valley frogs was recently established on a ranch just outside the western border of the RU. We are not aware of Chiricahua leopard frog locality records from the Sonoran portion of the RU; however, given the proximity of the Sierra Cibuta to localities in Arizona, the species certainly must have occurred, and likely still occurs there. Chiricahua leopard frogs are unknown from the Sierrita Mountains, although a population occurred near the southern base of the mountains historically. The Sierritas reach an elevation of nearly 6,000 feet and likely include habitat for the species. This mountain range has been poorly surveyed for leopard frogs.

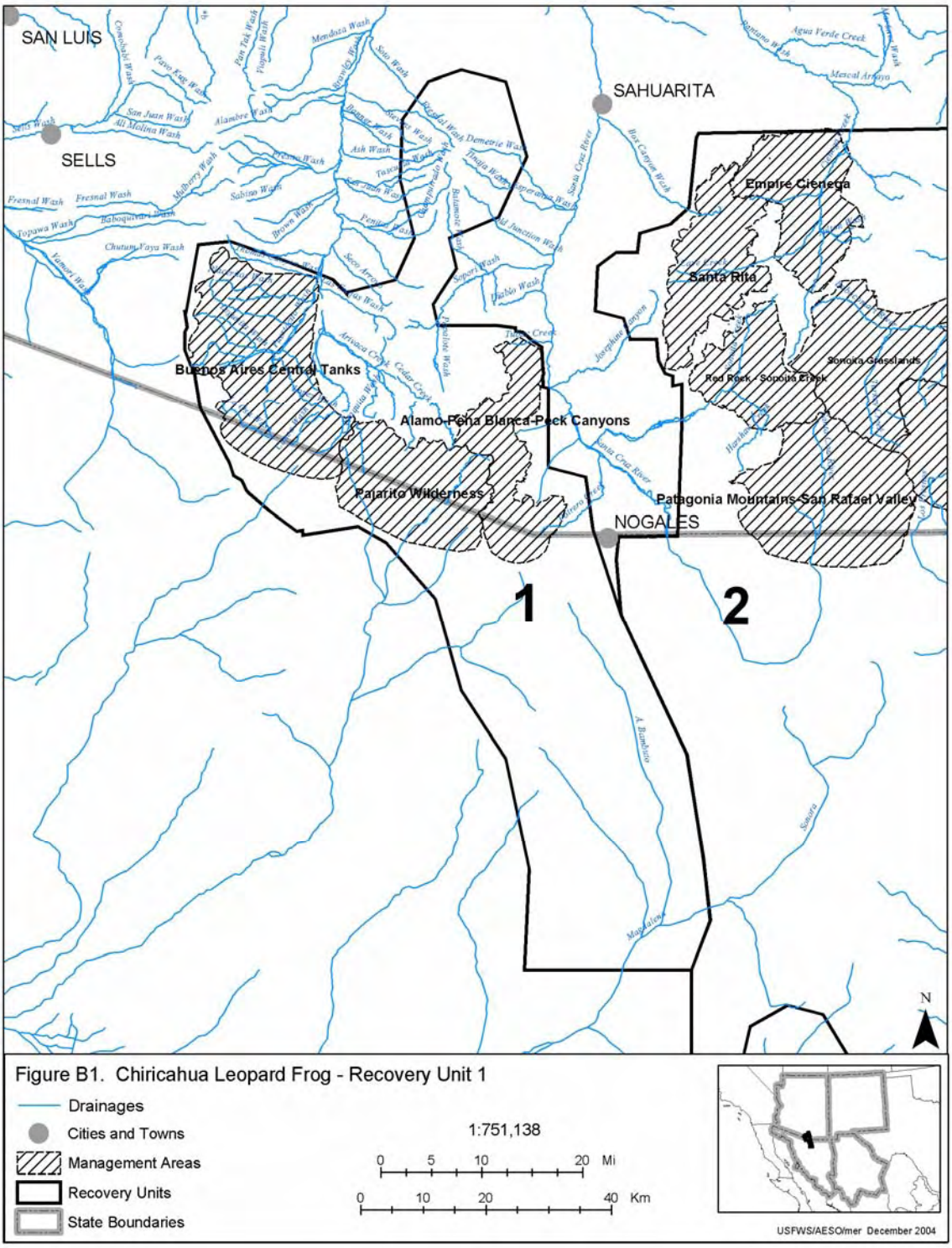


Figure B1. Chiricahua Leopard Frog - Recovery Unit 1

Current Land Uses and Management

The mountainous regions of the Arizona portion of the RU are managed primarily by the Nogales Ranger District of the Coronado National Forest. Private in-holdings are relatively few, but include lands near Calabasas, California Gulch/Warsaw/Holden canyons area, at Ruby, and upper Tres Bellotas Canyon. The northern portions of the RU extend up through State and private lands near Arivaca into the Sierrita Mountains. The higher portions of the Sierritas are managed by the BLM's Tucson Field Office, as are scattered parcels to the south, including most of the Las Guijatas Mountains. Between the Sierrita Mountains and Arivaca, and westward across the Altar Valley lie many thousands of acres of lands managed by the Arizona State Lands Department. The 118,000-acre Buenos Aires NWR, in the center of Altar Valley, was established in 1985 for recovery of the endangered masked bobwhite. The refuge has been engaged in reintroducing fire to the landscape to restore grasslands and bobwhite habitat for several years.

Significant private ranches occur in the Altar Valley and Arivaca area. The Altar Valley Conservation Alliance is a group of 11 ranches comprising 400,000 acres. The main focus of the alliance is prevention of rangeland erosion, but they have worked with the USFWS on a draft habitat conservation plan for the protection of threatened and endangered species and a Safe Harbor Agreement for the Chiricahua leopard frog.

Forest Service lands are managed in accordance with the Coronado National Forest's 1986 Forest Plan. Primary uses in the area include various forms of dispersed recreation, livestock grazing, mining, and fuelwood harvest. The Ruby Road corridor is popular with campers, birders, hunters, and hikers. The 45-acre Pena Blanca Lake, constructed in 1958, provides fishing; however, the lodge and restaurant are now closed. Arivaca Lake also is fished; however, the Arizona Department of Environmental Quality recommends not eating fish caught in the lake due to contamination. A private, small lake is located at Ruby, which is open to the public for a small fee. All three lakes are or have been stocked with warm water non-native fishes, such as largemouth bass and channel catfish. The 7,553-acre Pajarita Wilderness straddles the U.S./Mexico border and includes Sycamore Canyon.

Mining is represented by mostly historical evidence in the form of abandoned shafts, tunnels, and adits. These features are particularly common from Ruby south into California Gulch, at Warsaw and Holden canyons, and in Las Guijas Mountains.

The BLM lands are managed under the 1988 Phoenix District Resource Management Plan. The scattered and often isolated location of BLM lands make them relatively difficult to manage. Primary uses include livestock grazing and recreation. Arizona State Land Department manages State Trust lands and resources to enhance value and optimize economic return for the Trust's beneficiaries, which are primarily schools from Kindergarten through High School. Livestock production is a primary use of State Trust lands in RU 1.

Land uses and management in Sonora are poorly known. However, the RU includes no forest reserves or other special management areas or designations. Major land uses include ranching, some small farms, and small communities. Lands are primarily ejido and privately-owned.

Ejidos are collective landholdings, which were first established following the Mexican Revolution when land was confiscated from large landholders and redistributed to the peasantry. A 1992 amendment of Article 27 of the Mexican Constitution known as the Agrarian Law granted ejidatarios (owners of ejidos) the right to rent, sell, or mortgage their ejido lands. This has lead to increased privatization of former ejido lands in RU 1 and elsewhere in Mexico (Lewis 2002).

Threats

A History of Land Uses - Past and Current Threats

The history of RU 1 is different in the eastern portion than in the western portion due to the substantial differences in water resources of the Santa Cruz River basin in the east and the Altar Valley basin in the west. The Santa Cruz River basin had perennial and intermittent flows from prehistoric times well into the 20th century. The Altar Valley basin, on the other hand, is not known to have had significant water resources in its northern or southern drainages until wells were developed in the 1880s to support livestock operations.

Prehistoric mounds are found throughout in the Altar basin dating to the Classic or late Hohokam period, 500 to 850 years ago. It is reasonable to assume that Hohokam or Pima Indians practiced some floodwater farming in the Altar basin. In both the Altar and Santa Cruz drainages artifacts can be found throughout the mountain locations indicating at least seasonal use of these resources in prehistoric periods. Permanent farming communities are known in the Santa Cruz basin from the Middle Archaic period -- as long as 4,000 years ago, and in the Arivaca Cienega area 500 to 850 years ago. Historic settlements continued in those areas, interrupted by the Pima uprising of 1751, and expanded into the Altar Valley and other dry portions of the RU following the 1880s, except for periods in the 19th century interrupted by Apache raids on Euro-American settlements.

Spaniards began silver and gold mines in the RU in the 18th century. Mining activities at and near Ruby began in earnest in 1854. The Montana Mine was established in the area in the 1870s. Mining operations entailed the cutting of trees for timbers and fuel, but the extent of cutting is unknown. Fuelwood cutting in the Altar Valley in the late 19th and early 20th centuries supported mechanical well pumping in the valley center.

In the 1850s, Pedro Aguirre, Jr. started a stagecoach and freight line between Tucson and the mining towns of Arivaca in Arizona, and Altar in Sonora, Mexico. He added a homestead in 1864 and named it Buenos Ayres, or "good air," for the constant winds found there. Pedro Aguirre drilled the first well in the Altar Valley. He built earthen dams near the homestead, and the water that was retained created Aguirre Lake, which is now located near the headquarters of the Buenos Aires NWR. New deep wells assured a water supply for cattle in the Altar Valley. Overgrazing followed by severe drought from 1885-1892 resulted in degradation of grasslands and cessation of periodic fires, which likely began the process of shrub and tree invasion that characterizes the Altar Valley today.

Threats Assessment: 2004-2014

Tables B1 and B2 display the results of the threats assessment for RU 1. Extraordinary predation was ranked as the most important stressor to the frog in this RU, with American bullfrogs and crayfish ranked as the most important non-native predators. Non-native fishes and salamanders also contribute to extraordinary predation. American bullfrogs are widespread in this system, and if crayfish become widely distributed, the two together could preclude effective recovery. American bullfrogs have recently invaded Sycamore Canyon, which is probably the most important habitat and the source for a metapopulation in this RU. Reproduction and possible recruitment by American bullfrogs in Sycamore Canyon was first recorded in 2004-5. Efforts are underway to eliminate bullfrogs from the canyon. Pena Blanca Lake, Arivaca Cienega/Lake, and Ruby Lake are sources of American bullfrogs and other non-native predators. Infectious disease (chytridiomycosis), and aquatic habitat degradation and loss were the next most important stresses. Chytridomycosis is present in Sycamore Canyon, but the frogs have coexisted with the disease there since at least 1972. Drought, catastrophic fire, and hydrologic alterations (dams, diversions, groundwater pumping, etc) are the most important contributors to aquatic habit loss and degradation. Contaminants and reduced connectivity were ranked as medium stressors. The most important sources of stress in regard to contaminants were smelter emissions and catastrophic fire (e.g. ash flow and fire retardants). Effects of copper smelters may have had lasting effects, and the smelter at Cananea, although currently closed, could potentially reopen in the future. The most important contributors to reduced connectivity are dirt stock tank management, drought, and hydrologic alteration, in that order.

Past or Ongoing Chiricahua Leopard Frog Conservation

On the National Forest lands, little specific management has occurred for Chiricahua leopard frogs. However, in the 1990s, the Nogales Ranger District constructed several rock and log wing dikes in the Sycamore Canyon to protect the Hank and Yank Spring box from bank erosion that threatened to undermine the spring. The spring box has been a refuge for frogs when contaminants, disease, or other factors have reduced populations in the creek (Hale and Jarchow 1988). In 2005, volunteers, AGFD, and Cecil Schwalbe initiated efforts to eliminate American bullfrogs from Sycamore Canyon. Beginning in 2002, the Coronado National Forest consulted under section 7 of the ESA with USFWS regarding effects of livestock grazing on the Chiricahua leopard frog and other listed species. At that time some modifications were built into allotment management plans to ensure continued habitat suitability for frogs.

Efforts have been underway at Buenos Aires NWR to eliminate populations of bullfrogs and other non-native predators in preparation for reestablishment of the Chiricahua leopard frog. Techniques were developed for predator removal from livestock tanks (Schwalbe *et al.* 2000); and predators were removed from several areas, but approvals were not obtained for subsequent reestablishment of Chiricahua leopard frogs.

The Altar Valley Conservation Alliance has been working with the USFWS and AGFD on a Safe Harbor Agreement for the Chiricahua leopard frog, and discussions have occurred about habitat conservation planning as well. In 2004, a refugium Chiricahua leopard frog population was established in a closed livestock tank on a private ranch just west and north of the RU. This

refugium could supply animals for reestablishment, if Safe Harbor Agreements or other mechanisms are put in place with landowners.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	Very High	Very High
Infectious Disease	High	Very High	High
Aquatic patch degradation	High	High	High
Aquatic patch loss	Very High	High	High
Contaminants	Medium	Medium	Medium
Reduced connectivity	Medium	Medium	Medium

Table B1: Recovery Unit 1: Viability Summary

Management Areas

Three MAs are designated in RU 1 (Figure B1). The Buenos Aires Central Tanks MA includes portions of the Altar Valley, including Buenos Aires NWR, that have been the focus of recovery actions and a developing Safe Harbor Agreement with local landowners. The Pajarita Wilderness MA includes Sycamore Canyon and associated tanks where there is an extant metapopulation centered on Sycamore Canyon. The Alamo- Peña Blanca-Peck Canyons MA is an area of mostly former occupation, although frogs have been observed on the eastern portion of the MA in recent years. All three MAs extend into Sonora, based on adjacent montane terrain that likely contains suitable habitat and perhaps populations of Chiricahua leopard frogs.

Buenos Aires Central Tanks MA (potential for metapopulation and buffer). Includes the Puertocito Wash HU (all) and El Rio Sasabe Headwaters HU (all). The MA includes Buenos Aires NWR, private lands, and portions of the Coronado National Forest. The frog is extant at several localities in the MA.

Pajarita Wilderness MA (metapopulation, isolated population [Pajarito Border], and buffer). Includes the Rio Altar Headwaters HU (all), including Sycamore Canyon and associated Rio Altar drainages. Portions of Sonora adjacent to the Rio Altar Headwaters HU have been included in the MA. An extant metapopulation of frogs is centered on Sycamore Canyon.

Alamo-Peña Blanca-Peck Canyons MA (metapopulation [Peck Canyon], isolated population [Alamo and Peña Blanca canyons], and buffer). Josephine Canyon-Upper Santa Cruz River HU (only portions of this HU above 3,800 feet elevation) and Portrero Creek-Santa Cruz River HU (only portions of this HU that includes the drainage where Monument Tank is located). Adjacent lands in Sonora with potential for Chiricahua leopard frogs have also been included.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	Very High	High				Low	Very High
	Irreversibility	High	High				High	
	Override							
	Source	Very High	High				Medium	
	Combined Rank	Very High	High				Low	
Non-native fishes	Contribution	High					Low	High
	Irreversibility	Medium					Medium	
	Override							
	Source	Medium					Low	
	Combined Rank	High					Low	
Crayfish	Contribution	High		Low	Medium		Low	Very High
	Irreversibility	Very High		Very High	Very High		Very High	
	Override							
	Source	High		Medium	High		Medium	
	Combined Rank	Very High		Medium	High		Low	

Table B2: Recovery Unit 1: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Non-native tiger salamander	Contribution	Low	Low					High
	Irreversibility	High	High					
	Override							
	Source	Medium	Medium					
	Combined Rank	High	Medium					
Chytrid fungus	Contribution		Very High					High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		High					
Dirt stock Tank Manage-ment	Contribution	High		Medium	Low		Very High	High
	Irreversibility	Low		Low	Low		Low	
	Override							
	Source	Medium		Low	Low		High	
	Combined Rank	High		Low	Low		Medium	
Poor Grazing Practices	Contribution			Low		Low	Low	Low
	Irreversibility			Medium		Low	Low	
	Override							
	Source			Low		Low	Low	
	Combined Rank			Low		Low	Low	

Table B2: Recovery Unit 1: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution	Low	Low	Medium	High	Medium	Low	High
	Irreversibility	Low	Low	High	High	Low	High	
	Override							
	Source	Low	Low	Medium	High	Low	Medium	
	Combined Rank	Medium	Low	Medium	High	Low	Low	
Drought	Contribution			High	High		High	Medium
	Irreversibility			Medium	Medium		Low	
	Override							
	Source			Medium	Medium		Medium	
	Combined Rank			Medium	Medium		Low	
Hydrologic Alteration	Contribution	High		Medium	High		Medium	Very High
	Irreversibility	High		High	High		High	
	Override							
	Source	High		Medium	High		Medium	
	Combined Rank	Very High		Medium	High		Low	
Recreation	Contribution	High	Medium	Medium				High
	Irreversibility	High	Medium	Medium				
	Override							
	Source	High	Medium	Medium				
	Combined Rank	Very High	Medium	Medium				

Table B2: Recovery Unit 1: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Smelter Emissions	Contribution					Medium		Low
	Irreversibility					High		
	Override							
	Source					Medium		
	Combined Rank					Low		
Surface Disturbance	Contribution			Medium	Medium			Medium
	Irreversibility			Low	High			
	Override							
	Source			Medium	Medium			
	Combined Rank			Medium	Medium			
Iridovirus	Contribution		Low					Low
	Irreversibility		High					
	Override							
	Source		Low					
	Combined Rank		Low					
Border Issues	Contribution		Low	Medium	Low	Low		Medium
	Irreversibility		High	Medium	Medium	Medium		
	Override							
	Source		Medium	Medium		Low		
	Combined Rank		Medium	Medium		Low		

Table B2: Recovery Unit 1: Sources of Stress

RECOVERY UNIT 2: SANTA RITA-HUACHUCA-AJOS/BAVISPE

Environmental Setting

RU 2 is located in portions of Cochise, Santa Cruz, and Pima counties, Arizona and adjacent portions of northern Sonora (Figure B2). This RU includes the upper reaches and headwaters of the San Pedro and Santa Cruz rivers, as well as the headwaters of the Rios Sonora, Magdalena, and Bavispe. Elevations vary from 9,466 feet on Miller Peak in the Huachuca Mountains to less than 4,000 feet at the western base of the Sierra de Pinitos and on Sonoita Creek downstream of Patagonia. Vegetation communities include semi-desert grasslands at the lower elevations, climbing through oak and pine-oak woodlands to stands of mixed conifer forests. The latter are restricted to the higher elevations of the Santa Rita and Huachuca Mountains in Arizona, and to the Sierra de los Ajos, Sierra Cananea, Sierra Azul, and the southern portions of the Sierra Pinitos in Sonora (Brown and Lowe 1980).

Chiricahua Leopard Frog Populations

In this RU, Chiricahua leopard frogs are known historically from montane canyons below about 6,230 feet and in valleys above about 4,000 feet. Historically they inhabited canyons such as Scotia Canyon in the Huachuca Mountains and Big Casa Blanca Canyon in the Santa Rita Mountains; valley bottom cienegas, such as Sheehy Spring and the Empire Cienega in the upper Santa Cruz River drainage; as well as major rivers, such as the San Pedro and Santa Cruz. Platz and Mecham (1979) list only a single locality in Sonora from RU 2: on the Rio Santa Cruz 4 miles south of the international boundary. However, the frog has been reported from the Ajos – Bavispe region (The Nature Conservancy undated), including Canon Evens in the Sierra los Ajos (Hale pers. comm. 2004); leopard frogs (possibly Chiricahua leopard frogs) reportedly occur at the Los Fresnos Cienega and the Rancho Las Palmitas in the upper San Pedro River drainage (IMADES 2003); and likely also occur or occurred in other mountain ranges and valleys elsewhere in the Sonoran portion of RU 2.

Chiricahua leopard frogs are still well-represented in RU 2, including populations on the eastern slope of the Santa Rita Mountains, Patagonia Mountains, Canelo Hills, Empire Cienega/Cienega Creek, Monkey Springs, Ajos-Bavispe area/upper San Pedro River basin, and San Rafael Valley. The Ramsey Canyon leopard frog also occurs in several canyons on the eastern slope of the Huachuca Mountains. This species is treated here as a synonym for the Chiricahua leopard frog.

Current Land Uses and Management

In Arizona, management of occupied and historical habitats is primarily by the Coronado National Forest (Huachuca, Santa Rita, Patagonia mountains; Canelo Hills; and the upper portions of the San Rafael Valley). The BLM manages important habitat at the Empire Cienega/Cienega Creek (Las Cienegas National Conservation Area) and formerly-occupied habitat along the San Pedro River Riparian National Conservation Area, while the Army's Fort Huachuca manages the northeastern portion of the Huachuca Mountains. The National Park Service manages Coronado National Memorial in the southern end of the Huachuca Mountains.

Private lands occur throughout the RU, with major inholdings in the center of the San Rafael Valley (San Rafael Ranch), in the Sierra Vista/Hereford/Huachuca City area, at and near Sonoita, and along Sonoita Creek. Arizona State Land Department manages relatively few lands in RU 2, with the largest parcels at and near Patagonia Lake State Park and in the Sierra Vista area. The Sonoita Valley Planning Partnership provides a forum for the community (private, public, government, local, non-local) to come together to resolve local and national issues affecting public lands in the Sonoita Valley. The Upper San Pedro Partnership, a similar coalition, addresses water use and conservation, and other issues in the upper San Pedro River valley.

Management in Sonora is primarily for ranching and mining (especially at Cananea). SEMARNAT (Mexico's Federal Secretary for the Environment, Natural Resources, and Fisheries) manages the 184,698 ha El Bosque Nacional y Refugio de Vida Silvestre Los Ajos-Bavispe. In RU 2, this national forest and wildlife refuge includes the Sierra de los Ajos, Buenos Aires, and La Purica and is part of the largest forest reserve in the Sierra Madre Occidental. Rancho Los Fresnos in the southern portion of the San Rafael Valley was recently acquired by Naturalia (a Mexican NGO) with a conservation easement owned by The Nature Conservancy. This approximately 10,000 acre ranch is being managed for its intact native grasslands, cienegas, and stream habitats.

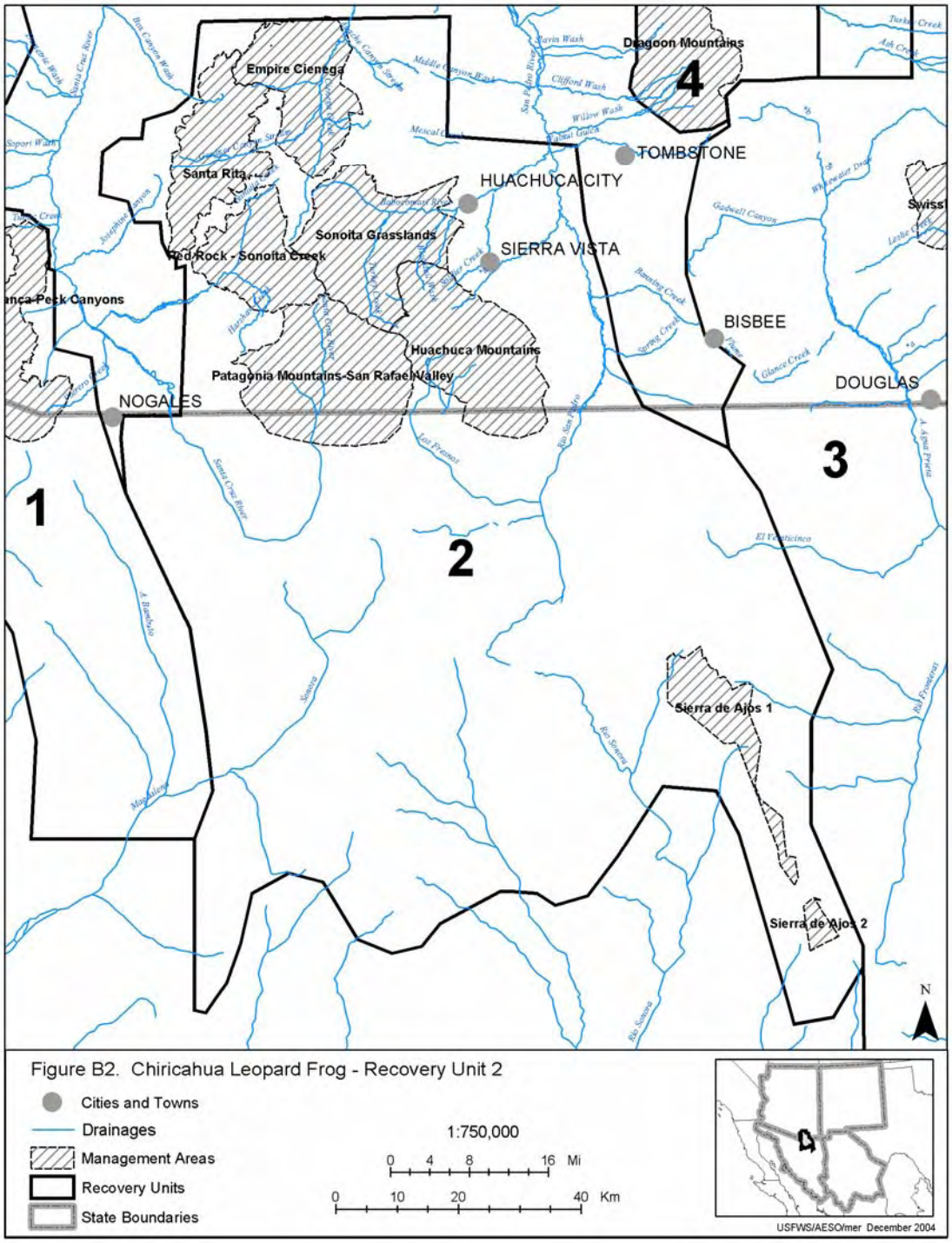
Threats

A History of Land Uses - Past and Current Threats

Historically, livestock grazing, mining, and timber harvest were probably the primary land uses that affected frogs and their habitats in RU 2. All likely caused tremendous changes in frog habitats in the late 19th century. Completion of two cross-continental railways across Arizona in the 1880s, military take-over of the Chiricahua Apaches, and discovery of extensive silver deposits near Tombstone in the late 1870s spurred a boom in the mining and livestock industries and facilitated settlement and development of the area (Rogers 1965, Sheridan and Hadley 1995).

Evidence of historical mining activity is commonly encountered throughout the mountain ranges in RU 2 (Taylor 1991, Hereford 1993, Hadley and Sheridan 1995). Direct impacts of mining, such as tailings piles, roads, areas cleared for settlements, and probably most importantly, fuelwood harvest to support the mines and settlers, likely resulted in localized denuded landscapes and degraded watersheds (Hadley and Sheridan 1995.) A sawmill operated near the mouth of Sawmill Canyon, Huachuca Mountains, from 1879-1882. Other sawmills operated in Carr, Ramsey, Sunnyside, and Miller canyons (Taylor 1991). By 1902 all usable timber had been harvested from the Huachuca Mountains [General Wildlife Services undated (draft report)].

Watershed degradation caused by extensive mining, wood cutting, and heavy grazing exacerbated the effects of unusually heavy rainfall after a severe drought in the early 1890s, resulting in entrenchment of the San Pedro River and loss of cienega habitats throughout southeastern Arizona (Jackson *et al.* 1987, Hendrickson and Minckley 1984, Geraghty and



Miller, Inc. 1995, Hadley and Sheridan 1995). Loss of beaver from the San Pedro and Santa Cruz rivers as a result of overharvest likely contributed further to loss of pool and cienega habitats for frogs. The San Pedro River in the middle 19th century was described as a "marshy

bottom with plenty of grass and water" (Cooke 1938), with boggy banks, swampy conditions (Eccleston 1950) and fewer trees than we see today (Leach 1858, Parke 1857).

Fire frequency and intensity in the mountains of RU 2 are altered from historical conditions. For instance, before 1870 and the establishment of Fort Huachuca (1877), fires in the Huachuca Mountains were frequent (mean frequency of 4-8 years), low-intensity (ground fires), and widespread. Since 1870, only two widespread fires have occurred (1899 and 1914). Danzer *et al.* (1997) attribute this change in fire regime to extensive use of timber, mineral, range, and water resources, and associated reductions in fuel loads. Active fire suppression by the Forest Service and others also reduced fire frequency. Exclusion of fire has promoted encroachment of shade-tolerant, less fire resistant tree species such as Douglas-fir, gambel oak, and southwestern white pine, and inhibited growth of Pondersosa pine. The 1899 fire was a devastating crown fire that halted all large-scale logging operations at the "Reef" in Carr Canyon and below Ramsey Peak (Danzer *et al.* 1997.) Danzer *et al.* (1997) suggest that the fire regime has been altered from frequent, low intensity fire to infrequent, stand-replacing fires. Recent stand-replacing fires on Carr Peak, Miller Peak, and Pat Scott Peak support this hypothesis.

This change in fire frequency and intensity precipitated loss of frog habitats in montane canyons as a result of severe erosion and sedimentation following stand-replacing fire; however, the extent of that loss is difficult to reconstruct. As mentioned in the “Reasons for Listing/Threats” in Part 1, leopard frogs apparently disappeared from Miller Canyon in the Huachuca Mountains, Arizona, following a 1977 crown fire in the upper canyon and subsequent erosion and scouring of the canyon during storm events (Tom Beatty, Miller Canyon, pers. comm. 2000). Other lines of evidence, such as lack of habitat in canyons formerly occupied by leopard frogs, also support a hypothesis that changes in fire regimes have been detrimental to leopard frogs. Although the Huachucas have probably been affected the most by wildfire, similar habitat loss has probably occurred in the Santa Rita Mountains, and stand-replacing fire threatens montane canyon habitats in all of the mountain ranges in the RU.

Mexicana de Cananea Company operates one of the ten largest open pit copper mines in the world at Cananea (U.S. Bureau of Land Management 1998). Acidic water from leach ponds spilled into the San Pedro River on several occasions from 1977-79, with resulting pHs as low as 3.1, low dissolved oxygen, and high levels of iron, copper, manganese, zinc, and suspended solids. Large die-offs of aquatic animals were noted (Jackson *et al.* 1987), and the Chiricahua leopard frog has not been observed in the San Pedro River since 1979. Until 1999, a copper smelter operated at the mine that affected air quality throughout the RU. As discussed in the “Reasons for Listing/Threats”, acid precipitation and high levels of sulfate, arsenic, cadmium, copper, lead, and zinc deposited during rainfall events may have affected frogs. Other smelters at Douglas (closed) and Nacozari (operating, but now has scrubbers) contributed to degraded air quality. Mine tailings from historical mining in some drainages may contain toxic materials that could leach into streams, causing toxic conditions. With the exception of the mine at Cananea, mining currently has little effect on Chiricahua leopard frogs. A large copper mine was proposed for the northern end of the Santa Rita Mountains in the 1990s, but the proposal has been shelved.

Non-native predators of leopard frogs, including several fishes, crayfish, tiger salamanders, and American bullfrogs have been introduced throughout RU 2, although some species have limited distributions (e.g. non-native tiger salamanders are primarily east of the Huachuca Mountains, crayfish are absent from the center of the San Rafael Valley). Non-native predators are uncommon in the mountains of the Sonoran portion of Unit 2, but major drainages such as Rio Santa Cruz and Rio San Pedro host numerous non-natives. Parker Canyon Lake, Patagonia Lake, and the San Pedro and Santa Cruz rivers serve as sources for non-native predators. Presence of non-natives precludes recovery potential for Chiricahua leopard frogs in many aquatic systems, unless those predators can be controlled. Non-native predators are the biggest threat to survival and recovery of the Chiricahua leopard frog in Unit 2. Chytridomycosis is present in several canyons on the eastern slope of the Huachuca Mountains (Ramsey Canyon leopard frog), and probably limits opportunities for recovery in Ramsey and perhaps other canyons. Chytridiomycosis is also present in Chiricahua leopard frogs at Cienega Creek, where the population is persisting at low levels with the disease.

Livestock grazing on the Coronado National Forest and BLM lands is much more limited and regulated compared to the heavy overgrazing that degraded watersheds and altered fire regimes in the late 19th century. However, damage to watersheds and aquatic habitats occurs locally, and is most apparent in drought years. The Coronado National Forest grazing program was addressed in section 7 consultation in 2002, and the BLM's grazing program was addressed in consultation in 1997. The Coronado National Forest built into their grazing program measures to protect the frog and its habitat, and terms and conditions in the biological opinion imposed further protective measures. Although the BLM has not yet addressed effects to Chiricahua leopard frogs in their grazing consultation, measures were included to protect aquatic and riparian systems on BLM lands throughout RU 2.

Recreation, urbanization in the Sierra Vista area, ranchettes near Sonoita, and other rural developments are all on the rise in Unit 2. The population of Sierra Vista increased from 24,937 in 1980 to 37,775 in 2000. With the planned development of the Whetstone Ranch housing project, Benson could grow from its current 5,000 to 70,000 people (San Pedro Expert Study Team 1999, Grimes 2004). Growth in the Sierra Vista/Fort Huachuca area and associated groundwater pumping threatens the baseflow of the San Pedro River (San Pedro Expert Study Team 1999); however, a team of local, State, and Federal representatives (The San Pedro Partnership) is developing plans and implementing projects to bring consumptive water use in line with groundwater supplies. The effort became international on June 22, 1999, when Interior Secretary Bruce Babbitt and Mexican Ambassador Jesus Reyes-Heroles signed a joint declaration to improve and conserve the natural and cultural resources of the upper San Pedro River basin, including the river and riparian corridor. The 2004 National Defense Authorization Act also included important language that will advance effective and timely protection for the San Pedro River. It recognized the efforts of the existing Upper San Pedro Partnership and established an oversight and funding role for Congress to achieve sustainable water use.

The Ajos-Bavispe National Forest and Wildlife Refuge is the largest federally-protected area in the Sierra Madre Occidental ecoregion and the only protected area in Mexico that is not decreed as one contiguous unit. Under the old reserve design the reserve is composed of five separate management units. Fraction number 4, which includes the Sierras de los Ajos, Buenos Aire and

La Purica, is in the southern portion of RU 2 and was designated a Federal reserve in 1939. It was poorly protected from illegal logging, poaching, and other activities until 1998 when Federal staff was assigned to the area.

Threats to Chiricahua leopard frogs and their habitats in Sonora are often less than that observed in Arizona. For instance, non-native predators are less common in the mountains of Sonora than in adjacent ranges in Arizona (E. Lopez, pers. comm. 2003). Swetnam and Baisan (1996) documented more natural fire regimes in the Sierra de los Ajos than in sky island ranges in Arizona, resulting in a lesser threat of catastrophic fires. They were impressed by the open character of the forests, abundance of grasses, and evidence of recent fires in the Sierra de los Ajos. Threats to natural resources of the Ajos-Bavispe region include mining, overgrazing, logging, illegal hunting, and inappropriate use of fire. Strategies have been designed to address these threats (SEMARNAP 1998, The Nature Conservancy undated). Overgrazing is more of a problem in the grasslands and savannas at the base of the Sierra del los Ajos than in the forests in the mountains (Swetnam and Baisan 1996).

Threats Assessment: 2004-2014

Tables B3 and B4 display the results of the threats assessment for RU 2. Consistent with the discussion of past and current threats, the greatest future threat to the frog in RU 2 is extraordinary predation, of which American bullfrogs and crayfish pose the greatest risk. Non-native species are widespread, particularly in the valley bottoms, and places such as Patagonia Lake, Parker Canyon Lake, and the San Pedro River provide significant sources and large populations of a diversity of non-native predators. Infectious disease (chytridiomycosis), and aquatic habitat degradation and loss, are the next most serious threats. As discussed above, chytridiomycosis has been documented at a few locations, but it is likely present at other sites, and will probably spread in the future. Development in the upper San Pedro River valley (e.g. Sierra Vista), Sonoita area, and Cananea, and threat of development elsewhere that may affect frogs and their habitats are significant in this RU. Contaminants and reduced connectivity are both medium threats to the frog. Airborne pollutants from the smelter at Cananea may have had lasting effects, and it could reopen in the future. Connectivity is influenced by a number of sources of stress, but stock tank management (or mismanagement), drought, and hydrologic alteration are particularly important. The threat of catastrophic fire and corresponding fire management or suppression contributes to all six stressors. This RU, as well as RUs 1 and 3, suffer from high levels of illegal cross-border activities, such as drug smuggling and illegal immigration, as well as law enforcement response. These activities increase the risk of catastrophic fire, disease spread, and aquatic habitat degradation.

The threats assessment focused on the U.S. portion of the RU; however, The Nature Conservancy (undated) conducted a threats assessment for the Sierras de los Ajos, Buenos Aires, and La Purica in the Ajos-Bavispe Reserve and Refuge. They found that the primary threats to the ecosystem were illegal hunting, inappropriate use of fire, logging, overgrazing, and mining. Illegal hunting was considered a “high” threat (but would have little effect on Chiricahua leopard frogs); overgrazing, inappropriate use of fire, logging, and overgrazing were “medium” threats, and mining was “low”.

Past or Ongoing Chiricahua Leopard Frog Conservation

The Ramsey Canyon leopard frog Conservation Agreement and Strategy, signed by several State, Federal, and private entities in 1996, is a model for local or regional leopard frog conservation. Since 1995, the Ramsey Canyon Leopard Frog Conservation Team has been protecting extant populations, maintaining and creating new habitats, and rearing and releasing metamorph leopard frogs and tadpoles. A major riparian restoration project is ongoing in Ramsey Canyon, which should in time enhance natural pool habitat. Several new frog populations have been established in Miller (Beattys Guest Ranch), Carr, and Ash canyons, and a model refugium has been established in the backyard of one of the cooperators in Sierra Vista (Mickey and Angel Rutherford). The conservation effort has had difficulties with chytridiomycosis, and the frog appears to be extirpated from the type locality (Ramsey Canyon) possibly as a result of this disease (Sredl *et al.* 2002).

Management Areas

In the Arizona portion of RU 2, recovery should build upon the efforts of the Ramsey Canyon Leopard Frog Conservation Team in the Huachuca Mountains MA. That group has focused on the eastern slope of the mountain range, but opportunities exist in Scotia and Sunnyside canyons, and likely other areas on the western slope, as well. Recovery efforts for the Chiricahua leopard frog could be coupled with recovery for the endangered Sonora tiger salamander (*Ambystoma tigrinum stebbinsi*) in the Patagonia Mountains-San Rafael Valley MA, an area that has other wetland or cienega conservation targets that could benefit as well (endangered Huachuca water umbel, *Lilaeopsis schaffneriana* spp. r*ecurva*; endangered Canelo Hills ladies tresses, *Spiranthes delitescens*; proposed Gila chub, *Gila intermedia*; and petitioned Mexican gartersnake, *Thamnophis eques*; among others). The Sky Island Alliance proposes to restore Bog Hole in the northern end of the valley for native amphibians and fishes. Another MA is the east side of the Santa Rita Mountains (Santa Rita MA) where Chiricahua leopard frogs exist in several canyons, and potentially could be expanded to other sites. Cienega Creek and the Post Canyon/O'Donnell Creek area in the Canelo Hills support Chiricahua leopard frogs and are designated parts of the Empire Cienega MA and Sonoita Grasslands MAs, respectively. The Red Rock-Sonoita Creek MA contains previously occupied habitat, but only one known extant population.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	Very High	Very High
Infectious Disease	High	Very High	High
Aquatic patch degradation	High	Very High	High
Aquatic patch loss	Very High	High	High
Contaminants	Medium	Medium	Medium
Reduced connectivity	High	Medium	Medium

Table B3: Recovery Unit 2: Viability Summary

In Sonora, the Sierra de los Ajos, Buenos Aires, and La Purica of the Ajos-Bavispe National Forest and Wildlife Refuge will be a MA for Chiricahua leopard frog. BIDA, Naturalia (Mexican NGOs), and The Nature Conservancy have developed proposals for habitat restoration work at Rancho Los Fresnos in the Sonoran portion of the San Rafael Valley and at the Rancho Las Palmitas north of Cananea. These efforts would complement recovery in the Patagonia Mountains-San Rafael Valley MA and in the nearby Ajos-Bavispe area.

Santa Rita MA (potential for metapopulation and buffer). Includes Box Canyon Wash-Upper Santa Cruz River HU (only portions of this HU in the Santa Rita Mountains above 5,000 feet elevation), Cienega Creek HU (only portions of this HU in the Santa Rita Mountains above 5,000 feet elevation), and Sonoita Creek HU (only portions of this HU in the Santa Rita Mountains that is north and west of Sonoita Creek).

Empire Cienega MA (potential for metapopulation or isolated population and buffer). Includes the Cienega Creek HU (but only portions of this HU above 4,500 feet and below 4,900 feet elevation).

Red Rock-Sonoita Creek MA (potential for metapopulation or isolated population [Red Rock], and buffer). Includes Sonoita Creek HU (only portions of this HU above 4,200 feet and below 4,500 feet elevation).

Sonoita Grasslands MA (potential for metapopulation and buffer). Includes Babocomari River HU (only portions of this HU not included in the Huachuca Mountains MA, above 4,500 feet and below 5,500 feet elevation).

Patagonia Mountains-San Rafael Valley MA (potential for metapopulation and buffer). Includes San Rafael Valley-Upper Santa Cruz River HU (only portions of this HU not in the Huachuca Mountains MA and below 5,500 feet elevation).

Huachuca Mountains MA (potential for metapopulation and buffer). Includes San Rafael Valley-Upper Santa Cruz River HU (only portions of this HU above 5,700 feet elevation), Babocomari River HU (only portions of this HU included in the Huachuca Mountains above 5,500 feet elevation), Walnut Gulch-Upper San Pedro River HU (only portions of this HU in the Huachuca Mountains above 5,000 feet elevation), Banning Creek-Upper San Pedro River HU (only portions of this HU in the Huachuca Mountains above 4,700 feet elevation). Montezuma Canyon-Upper San Pedro River HU (only portions of this HU in the Huachuca Mountains above 5,000 feet elevation), and Las Nutrias Headwaters HU (only portions of this HU in the Huachuca Mountains above 5,500 feet elevation).

Ajos-Bavispe West (potential for metapopulation and buffer). The entire area designated as fraction 1 (Sierra los Ajos, Buenos Aire y la Purica) of the Ajos-Bavispe National Forest and Wildlife Refuge is considered an MA. The area includes headwaters of the Rios San Pedro, Bavispe, Yaqui, and Sonora. Chiricahua leopard frogs have been found in the Sierra de los Ajos, but the current status of populations in the refuge is unknown.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	High	Medium				Low	Very High
	Irreversibility	High	High				High	
	Override							
	Source	High	Medium				Medium	
	Combined Rank	Very High	Medium				Low	
Non-native fishes	Contribution	High					Low	High
	Irreversibility	Medium					Medium	
	Override							
	Source	Medium					Low	
	Combined Rank	High					Low	
Crayfish	Contribution	High		Medium	Medium		Medium	Very High
	Irreversibility	Very High		Very High	Very High		Very High	
	Override							
	Source	High		High	High		High	
	Combined Rank	Very High		High	High		Medium	

Table B4: Recovery Unit 2: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Non-native tiger salamander	Contribution	Low	Low					High
	Irreversibility	High	High					
	Override							
	Source	Medium	Medium					
	Combined Rank	High	Medium					
Chytrid fungus	Contribution		Very High					High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		High					
Dirt stock Tank Manage-ment	Contribution	Medium		Low	Low		Very High	Medium
	Irreversibility	Low		Low	Low		Low	
	Override							
	Source	Low		Low	Low		High	
	Combined Rank	Medium		Low	Low		Medium	
Poor Grazing Practices	Contribution			Medium		Low	Low	Medium
	Irreversibility			Medium		Low	Low	
	Override							
	Source			Medium		Low	Low	
	Combined Rank			Medium		Low	Low	

Table B4: Recovery Unit 2: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution	Low	Low	High	High	Medium	Medium	High
	Irreversibility	Low	Low	High	High	Low	High	
	Override							
	Source	Low	Low	High	High	Low	Medium	
	Combined Rank	Medium	Low	High	High	Low	Low	
Drought	Contribution			High	High		High	Medium
	Irreversibility			Medium	Medium		Low	
	Override							
	Source			Medium	Medium		Medium	
	Combined Rank			Medium	Medium		Low	
Hydrologic Alteration	Contribution	High		High	High		High	Very High
	Irreversibility	High		High	High		High	
	Override							
	Source	High		High	High		High	
	Combined Rank	Very High		High	High		Low	
Recreation	Contribution	High	Medium	Medium				High
	Irreversibility	High	Medium	Medium				
	Override							
	Source	High	Medium	Medium				
	Combined Rank	Very High	Medium	Medium				

Table B4: Recovery Unit 2: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Smelter Emissions	Contribution					Medium		Low
	Irreversibility					High		
	Override							
	Source					Medium		
	Combined Rank					Low		
Surface Disturbance	Contribution			Medium	Medium	Low		Medium
	Irreversibility			Low	High	High		
	Override							
	Source			Medium	Medium			
	Combined Rank			Medium	Medium			
Iridovirus	Contribution		Low					Low
	Irreversibility		High					
	Override							
	Source		Low					
	Combined Rank		Low					
Border Issues	Contribution		Low	Medium	Low	Low		Medium
	Irreversibility		High	Medium	Medium	Medium		
	Override							
	Source		Medium	Medium		Low		
	Combined Rank		Medium	Medium		Low		

Table B4: Recovery Unit 2: Sources of Stress

RECOVERY UNIT 3: CHIRICAHUA MOUNTAINS-MALPAI BORDERLANDS-SIERRA MADRE

Environmental Setting

RU 3, which is by far the largest of the RUs (Figure 1, B3), includes basin and range topography, from west to east in Arizona and New Mexico, from the eastern slope of the Mule Mountains across the Sulphur Springs Valley to and including the Chiricahua Mountains, the Swisshelm, Pedregosa, and Perilla mountains, the San Bernardino Valley and the southern San Simon Valley on the Arizona/New Mexico border, east through the southern Peloncillo Mountains and the Guadalupe Mountains (southern end of the Peloncillo Mountains), across the Animals Valley and Animas Mountain into the Playas Valley. In Sonora, the RU includes the Sierra Anibacachi (south of the Mule Mountains), mountains in the headwaters of the Rios Bavispe and Nacozari, including the Sierra Nacozari, Sierra de Opusura, Sierra el Tigre, and Sierra San Luis complex. The RU also includes the northern Sierra Madre Occidental in both Sonora and Chihuahua, south to the Rio Papoqochic near Ciudad Guerrero in west-central Chihuahua (Platz and Mecham 1979).

Vegetation communities include semi-desert or plains grasslands, as well as Chihuahuan Desert scrub at lower elevations (below roughly 5,400 feet), Madrean evergreen woodlands above that to as high as 7,500 feet, with stands of petran montane conifer forests at the higher elevations. The latter include Ponderosa pine forests and, at the highest elevations, mixed conifer forests of Douglas fir, white fir, limber pine, and aspen. Extensive stands of petran montane conifer forests occur in the Sierra Madre Occidental, with smaller stands in the Sierra el Tigre, Chiricahuas, and other ranges (Brown and Lowe 1980). Logging has heavily impacted this vegetation type in portions of the Sierra Madre Occidental. A relictual stand of petran subalpine conifer forest occurs at the top of the Chiricahua Mountains, and includes Engelmann spruce and trees of the mixed conifer forest.

Chiricahua Leopard Frog Populations

The Chiricahua leopard frog is known historically from middle and lower elevations in this RU. They occurred in springs, cienegas, and livestock tanks in the Sulphur Springs, San Bernardino, Animas, and Playas valleys. They occurred historically in the Chiricahua, Swisshelm, Peloncillo, and Animas Mountains. They have not been recorded in the Mule Mountains, but occurred nearby at base of the mountains in the Sulphur Springs Valley. In Sonora, records exist for Cajon Bonito, Sierra San Luis; and near Agua Prieta. Platz and Mecham (1979) list nine localities for Chihuahua, including on the north, one in the Rio Casa Grandes drainage southeast of the Playas Valley, with the others on the eastern slope of the Sierra Madre Occidental south to near the Durango border. As discussed in the recovery plan, there is uncertainty concerning the taxonomy of the frogs from southern Chihuahua (Webb and Baker 1984). For the purposes of this recovery plan, we consider the southern distribution of the Chiricahua leopard frog and in Chihuahua and this RU to be the area of Rancho Lo Union on Rio Papoqochic in west-central Chihuahua. If frogs from farther south are confirmed as Chiricahua leopard frogs, the RU should be expanded to include those localities.

The Chiricahua leopard frog has declined dramatically in this RU (Rosen *et al.* 1994, 1996b). It is apparently extirpated from the Sulphur Springs Valley, has not been observed for many years in the Animas Mountains, may be extirpated from the Chiricahua Mountains (recent unconfirmed reports of leopard frogs from Rucker Canyon could be this species), and is limited to a very few localities in the San Bernardino, Animas, and Playas valleys. The species is still present in the Swisshelm Mountains, in the Cloverdale Creek area, and may still occur at one or more locations in the Peloncillo and Guadalupe mountains. It has been observed recently in the Sierra San Luis complex, but the status of other populations in Sonora and Chihuahua is unknown. Steve Hale (pers. comm. 2004), who has surveyed for ranid frogs in most of the mountain ranges in northeastern Sonora, believes the Sierra la Madera and the Pilares de Nacozari may not have perennial streams at a high enough elevation to support Chiricahua leopard frogs. Hale finds that the Sierra el Tigre, and Pilares de Teras and San Diego likely have suitable habitat, but he has not observed Chiricahua leopard frogs south of the Sierra Pan Duro in the Sierra San Luis complex.

Current Land Uses and Management

Land ownership and management in Arizona is a diverse mix of mostly National Forest, Arizona State Land Department, and private lands. The Coronado National Forest manages most of the Chiricahua and Peloncillo mountains. Arizona State Land Department owns and manages extensive lands in the Sulphur Springs, San Bernardino, and San Simon valleys, but extensive parcels of private lands occur in these areas as well, particularly in the Sulphur Springs Valley and in the Douglas area. The Mule Mountains are managed primarily by the Arizona State Land Department, with some private and BLM parcels. Elsewhere, the BLM manages mostly small isolated parcels, such as in the Peloncillo Mountains, in and near the Swisshelm Mountains, and the northeastern edge of the Chiricahua Mountains. The National Park Service manages Chiricahua National Monument in the northwestern portion of that range.

The largest part of the New Mexico portion of RU 3 is the privately-owned 321,000 acre Gray Ranch, owned by the Animas Foundation. The ranch includes most of the Animas Mountains, portions of the Peloncillo and Guadalupe mountains, and the Animas and Playas valleys. Most of the Peloncillo Mountains in New Mexico is managed by the Coronado National Forest. BLM and the State of New Mexico own lands on the eastern slope of the Animas Mountains and the Playas Valley. BLM also manages parcels in the Guadalupe Mountains.

The National Forest lands are managed in accordance with the 1986 Coronado National Forest Plan. Primary uses include recreation and livestock grazing, as well as some mining and other activities. BLM lands in Arizona are managed under the 1990 Safford District Resource Management Plan. Land uses are similar to the National Forest lands. Arizona State Land Department manages State Trust lands and resources to enhance value and optimize economic return for the Trust's beneficiaries, which are primarily schools from Kindergarten through High School. State Trust lands in RU 3 are managed primarily for livestock production.

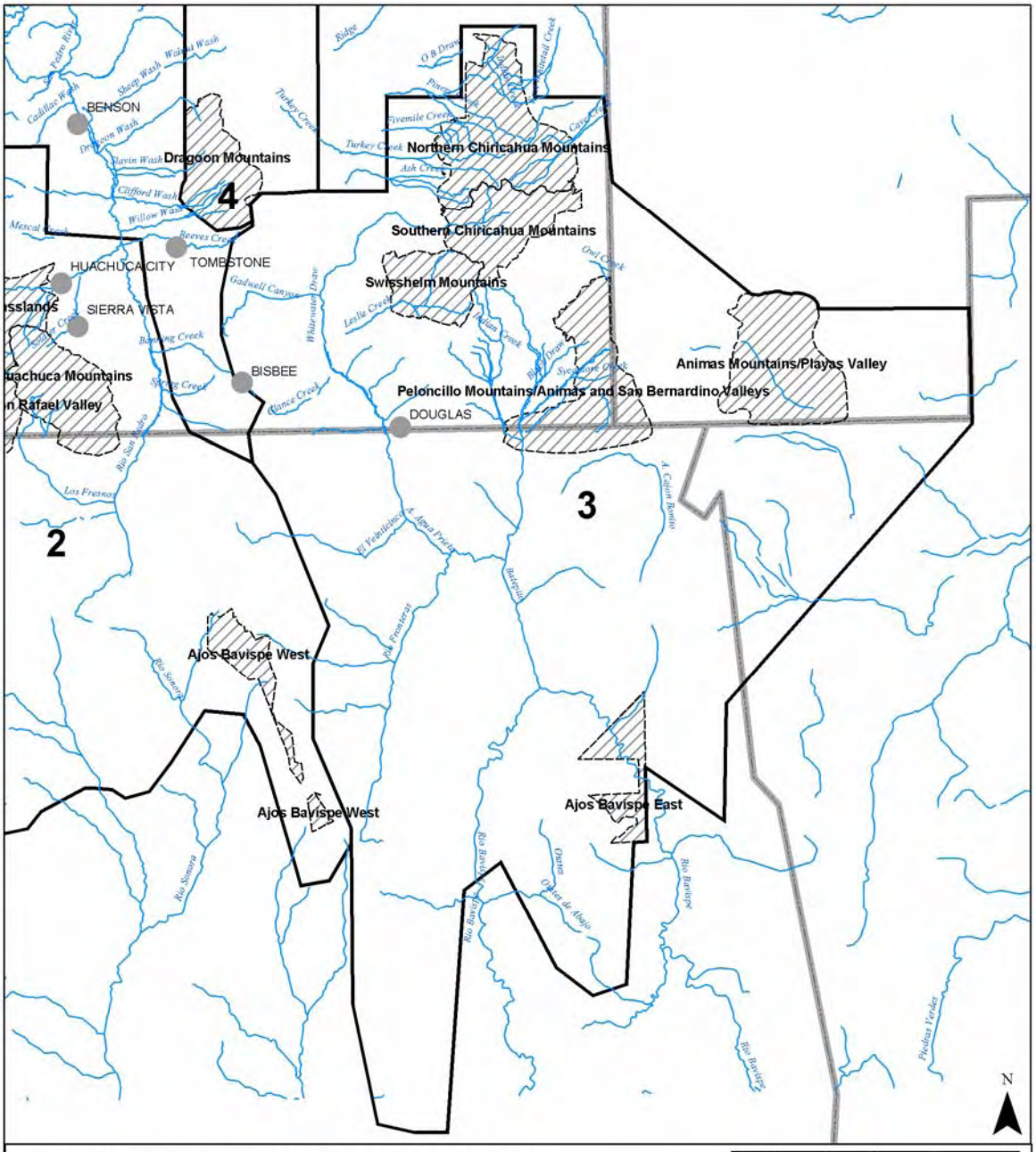


Figure B3. Chiricahua Leopard Frog - Recovery Unit 3

Cities and Towns
Drainages
Management Areas
Recovery Units
State Boundaries

1:1,115,000
0 5 10 20 Mi
0 15 30 60 Km

USFWS/AESO/mer December 2004

The Malpai Borderlands Group is led by a group of ranchers in extreme southeastern Arizona and southwestern New Mexico, which includes the Gray Ranch and nearby private ranches and properties. The Group has a goal of restoring and maintaining the natural processes that create and protect a healthy, unfragmented landscape to support a diverse, flourishing community of human, plant and animal life in the borderlands region. Malpai has employed the concept of "grassbanking" by which neighboring ranchers who were experiencing serious drought could rest their ranches from grazing by moving their herds to the Gray Ranch under reciprocal conservation agreements.

In Sonora, portions of the Sierras el Tigre and la Madera, and Pilares de Teras, de Nacozari, and San Diego are part of or "fracciones" of the Ajos-Bavispe Forest Reserve and Wildlife Refuge. Other lands in Sonora are primarily ejido or private lands, and are managed largely for livestock and timber production, as well as agriculture. Rangelands in Sonora are typically overstocked at densities 2-5 times the recommended stocking rate, often resulting in severe damage to vegetation and soils (Walker and Pavlakovich-Kochi 2003). Large parcels of ranchlands in the Sierra San Luis are owned by Americans that are members of the Malpai Borderlands Group. These lands are not as heavily grazed.

The conifer forests of the Sierra Madre Occidental have been severely degraded by logging and logging practices. Virtually all of the accessible areas in Chihuahua have been logged at least once. Old growth forests are restricted to inaccessible canyons, roadless areas, and steep slopes, primarily in southern Chihuahua. Forests have been genetically degraded by cutting all of the highest quality trees, and shelterwood cuts promote regeneration of only the most economically desirable species, at the expense of tree diversity. The Chihuahua spruce, once commonly distributed at low density throughout the higher elevations, is now nearly eliminated from the Sierra. At lower elevation, oaks and madrones are often scarce around communities due to cutting for firewood (Gingrich 2003). The greatest effects of these activities on Chiricahua leopard frogs may be via watershed degradation and resulting sedimentation, scouring, and increased flooding in the lower canyons where the frogs occur.

Cultivation of opium and marijuana occurs in the Mexican portion of RU 3, but its economic and environmental significance is unknown. Cultivation of these drugs in southern Chihuahua and Durango may be second only to logging in terms of the most important economic activities.

Threats

A History of Land Uses - Past and Current Threats

San Bernadino Valley

The first European settlement was by Spanish, who established a presidio in 1775. Accounts from that period indicated plentiful springs and cienegas. The presidio was abandoned in 1780, due to its isolation and repeated attacks by Apaches. Cattle grazing began in 1822, but active ranching did not occur in earnest until the San Bernardino Ranch was sold to John Slaughter in 1884. Earthquake struck the San Bernardino Valley in 1887. There were reports of new springs, disappearances of lakes and springs, and changes in water levels in wells. In 1891 and 1892 drought hit the San Bernardino Valley and John Slaughter sold 2,000 of his cattle leaving only 400 head. In the early 1900s Slaughter began to drill water wells on the San Bernardino

Ranch and hit artesian water, which flowed continuously, making several ponds. In the 1950s, AGFD and area sportsman began stocking ponds and several of the earthen stock tanks with sport fish and American bullfrogs for fishing and gigging. These introductions likely initiated the demise of the Chiricahua leopard frog from the ranch.

The San Bernardino Ranch today is part of the San Bernardino NWR, although the buildings are managed by the Johnson Historical Museum of the Southwest. Other lands in the RU include Arizona State School Trust, BLM, Forest Service and private lands. Cattle ranching remains the primary economic livelihood of the U.S. portion of RU 3. The majority of Chiricahua leopard frog populations are now dependent on man-made wells and earthen tanks

Chiricahua Mountains

Conrad Bahre (1995b) provides an account of late 1800s conditions and land uses in the Chiricahua Mountains based on a 1902 report and map of the range authored by A.F. Potter. Bahre describes a landscape at that time that was far from pristine, with many areas heavily disturbed by logging and livestock grazing. The following is taken from Bahre's work.

European settlement was minor (e.g. Fort Bowie and associated logging in Pine and Pinery canyons) until after the disestablishment of the Chiricahua Apache Reservation in 1876 (the reservation had been established only four years earlier). By 1902, much of the Chiricahuas had been grazed, logged, and cut over for fuelwood; and fire regimes had been altered from one of frequent ground fires to infrequent stand-replacing fires. The 1994 Rattlesnake Fire, which burned more than 27,000 acres, much of that catastrophically, was followed by severe erosion and sedimentation in downstream drainages. Rucker Lake, a former Chiricahua leopard frog locality, was buried in sediment and the canyon was scoured to a depth of 30 feet in some places.

Mining and smelters at Tombstone and Bisbee created a demand for timber and fuelwood in the late 1800s, and the completion of the Southern Pacific Railroad in 1881 opened up the rangelands to major livestock production. Eleven sawmills operated in the Chiricahuas between 1877 and 1902. By 1902, extensive cutting had occurred in Pine, Pinery, Morse, and Rucker canyons, and the forests in Morse and Rock canyons had been destroyed by logging. Most of the 24 cords of wood used daily by the Copper Queen smelter operation at Bisbee came from the Chiricahuas. High elevation mixed conifer forests were not much affected by logging because of their inaccessibility. Abusive logging practices lead to erosion and possible desiccation of some streams, and likely some loss of frog populations. Beaver were hunted out of the Chiricahuas during this same period, and the loss of pool and pond habitat behind beaver dams likely resulted in further declines of frogs and their habitats.

Livestock grazing did not become important in the Chiricahuas until 1878 or '79. The Chiricahua Cattle Company, formed in the 1880s, was grazing 30,000 cattle in the Chiricahuas and Sulphur Springs Valley before the drought of 1891-'93. Angora goats grazed Rucker Canyon and 20,000 sheep were pastured in the grasslands and meadows of the Chiricahuas at the same time. By 1902, most of the Chiricahuas were heavily grazed, although the northern end of the range never received much use due to rugged terrain. Removal of fine fuels by livestock caused or contributed to the cessation of frequent ground fires. Effective fire suppression by the middle of the 20th century further altered the fire regime.

Little mining occurred until after the disestablishment of the Chiricahua Apache Reservation. Most mining occurred in the northern portion of the range in the California or Chiricahua Mining District. A significant lead, silver, and copper mine and smelter operated at Galeyville from about 1880-'83. The Arizona Marble Company mined claims from Nine-Mile Canyon to Whitetail Canyon in 1909.

The Chiricahua Forest Reserve was established in 1902, a precursor to the Coronado National Forest. After the establishment of the Reserve, logging and over grazing were eventually brought under control. Today, major land uses in the Chiricahua Mountains include recreation (camping, hiking, biking, ecotourism, etc.), and cattle grazing.

Sulphur Springs Valley and Douglas

Humans reached the Sulphur Springs Valley at least 11,000 years ago. Spain claimed the area in 1539, but the Chiricahua Apache were the primary inhabitants until the late 1800s. In the 1870s cattle ranching became a major economic activity, followed shortly by mining. Dry farming was practiced on a small scale. Since the 1970s ranchetting and irrigation farming practices have grown to the point that groundwater pumping is lowering groundwater elevations. The town of Pearce was settled when John Pearce, a rancher, struck gold in this vicinity in 1894 establishing the Commonwealth Mine. A railroad station opened in Pearce in1903. The peak of production at the mine was reached in 1896, and the mine was worked into the 20th century. It is now closed.

Douglas was established in 1901 at a site known as Black Water. In 1904 a smelter was constructed to serve copper mines at Bisbee. During January 1918 the smelter produced over twenty million tons of fine copper. Smelting operations ended in the 1980s. Tourism and retirement living are now important factors in Douglas' economy.

As discussed in Part 1 of the recovery plan, the smelter at Douglas, as well as smelters at Cananea and Nacozari, Sonora, contributed to acid precipitation and may have caused, in part, observed high cadmium levels and associated die offs of Chiricahua leopard frogs and other ranid frogs in Arizona and Sonora.

Gray Ranch/Animas Mountains/Pelconcillo Mountains/Playas Valley

In 1990, The Nature Conservancy purchased the Gray Ranch and, in 1993, sold it with a conservation easement to the newly-formed Animas Foundation, an organization dedicated to protecting the natural values of the Gray Ranch while maintaining the cultural and economic heritage of the bootheel country. The Ranch includes portions of the Animas and Peloncillo mountains, and Animas and Playas valleys.

The Playas Valley is dotted by abandoned mine sites that in the late 1880s produced turquoise, silver, and other valuable ores. Phelps Dodge Corporation decided to build a copper smelter south of the old Playas Siding location on Playas Lake, in what was a remote desert area in the 1980s. A new company town was built for use by employees working at the new smelter. This town was named "Playas". But in 2000, the smelter was closed and employees were ordered to move out of Playas by June 1, 2000. Playas was purchased by New Mexico Tech in 2004 and is currently being used as a training site for counter-terrorism urban warfare by the Department of Homeland Security.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	Very High	Very High
Infectious Disease	High	Very High	High
Aquatic patch degradation	High	Very High	High
Aquatic patch loss	Very High	Medium	Medium
Contaminants	Medium	Low	Low

Table B5: Recovery Unit 3: Viability Summary

Threats Assessment: 2004-2014

Tables B5 and B6 display the results of the threat assessment for this RU. The greatest threat to the frog in this RU is extraordinary predation. Recovery may be precluded in the Sulphur Springs Valley due to prevalence of non-native predators. American bullfrogs are the most important contributor to that predation, but non-native fishes are also important. Non-native salamanders and crayfish contribute less to extraordinary predation than either American bullfrogs or non-native fishes, because frogs coexist to some degree with salamanders, and crayfish are not widely distributed in the RU. However, both have a high threat-to-system rank because of additional contributions to disease and aquatic habitat degradation and loss. Infectious disease (chytridiomycosis and possibly iridovirus), aquatic habitat degradation, and reduced connectivity are the next most important stressors in RU 3. Drought, catastrophic fire, and hydrologic alterations are the most important contributors to aquatic habitat degradation. Illegal immigration and smuggling, as well as law enforcement response, are contributing to habitat degradation. The threat of catastrophic fire is significant in the Chiricahuas, and possibly other ranges in RU 3. Drought over the last decade threatened or eliminated frog populations in the San Bernardino Valley and Cloverdale Creek area.

Hydrologic alterations, particularly those that favor non-native predators, cause both habitat degradation and reduced connectivity. Dirt stock tank management and drought are the most important contributors to reduced connectivity. Stock tanks are important habitats for frogs in RU 3, but they are sensitive to drought and management. Aquatic habitat loss is considered a medium threat. Development and loss of habitat is possible on state and private lands in the San Bernardino and Sulphur Springs valleys, but habitats on the Gray Ranch, Coronado National Forest, and San Bernardino and Leslie Canyon National Wildlife Refuges are secure. The threat of contaminants is considered low in RU 3. The greatest contributor to contamination is ash flow and fire retardants associated with catastrophic fire and fire suppression. The threat assessment focused on the U.S. portion of the RU; however, we believe threats are similar, but are generally of lesser magnitude in Sonora and Chihuahua. Logging and associated watershed degradation are important threats in the Sierra Madre Occidental.

Past or Ongoing Chiricahua Leopard Frog Conservation

Ranchers Matt and Anna Magoffin initiated some of the first recovery efforts for this species in RU 3 when in 1994 they discovered that Chiricahua leopard frogs at one of their livestock tanks were in danger of extirpation due to drying of the tank. The Magoffins hauled water to the tank in 1994 and 1995 to maintain the population. Subsequent reconstruction of the tank, including building a small concrete pond to sustain the frogs during drought, has further assured the continued persistence of this frog population. Wells were developed in 1995 and 1997 at two livestock tanks that support frogs, to ensure a dependable water supply.

Recovery efforts have also been undertaken at San Bernardino NWR, where in 1993, tadpoles were salvaged from the Magoffin's livestock tank and transferred to wetland sites on the refuge where American bullfrog control was underway (Rosen and Schwalbe 1998). Wetlands from which American bullfrogs were excluded were also developed, as well as a "ranarium" where frogs could be reared and bred. The frogs flourished initially, but in 1997 a die off began and frogs tested positive for chytridiomycosis.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	Very High	Medium				Low	Very High
	Irreversibility	High	High				High	
	Override							
	Source	Very High	Medium				Medium	
	Combined Rank	Very High	Medium				Medium	
Non-native fishes	Contribution	High					Low	High
	Irreversibility	Medium					Medium	
	Override							
	Source	Medium					Low	
	Combined Rank	High					Low	
Crayfish	Contribution	Low		Low	Low			High
	Irreversibility	Very High		Very High	Very High			
	Override							
	Source	Medium		Medium	Medium			
	Combined Rank	Very High		High	High			

Table B6: Recovery Unit 3: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Non-native tiger salamander	Contribution	Low	Medium					High
	Irreversibility	High	High					
	Override							
	Source	Medium	Medium					
	Combined Rank	High	Medium					
Chytrid fungus	Contribution		Very High					High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		High					
Dirt stock Tank Manage-ment	Contribution	Medium		Low	Low		Very High	High
	Irreversibility	Low		Low	Low		Low	
	Override							
	Source	Low		Low	Low		High	
	Combined Rank	Medium		Low	Low		High	
Poor Grazing Practices	Contribution			Medium		Low	Low	Medium
	Irreversibility			Medium		Low	Low	
	Override							
	Source			Medium		Low	Low	
	Combined Rank			Medium		Low	Low	

Table B6: Recovery Unit 3: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution	Low	Low	High	High	Medium	Medium	High
	Irreversibility	Low	Low	High	High	Low	High	
	Override							
	Source	Low	Low	High	High	Low	Medium	
	Combined Rank	Medium	Low	High	Medium	Low	Medium	
Drought	Contribution			High	High		Very High	High
	Irreversibility			Medium	Medium		Low	
	Override							
	Source			Medium	Medium		High	
	Combined Rank			Medium	Low		High	
Hydrologic Alteration	Contribution	Medium		High	High		High	Very High
	Irreversibility	High		High	High		High	
	Override							
	Source	Medium		High	High		High	
	Combined Rank	High		High	Medium		High	
Recreation	Contribution	High	Medium	Low				High
	Irreversibility	High	Medium	Medium				
	Override							
	Source	High	Medium	Medium				
	Combined Rank	Very High	Medium	Medium				

Table B6: Recovery Unit 3: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Surface Disturbance	Contribution			Low	Low	Low		Low
	Irreversibility			Low	Low	High		
	Override							
	Source			Medium	Medium			
	Combined Rank			Low	Low			
Border Issues	Contribution		Low	Medium	Low	Low		Medium
	Irreversibility		High	Medium	Medium	Medium		
	Override							
	Source		Medium	Medium		Low		
	Combined Rank		Medium	Medium		Low		

Table B6: Recovery Unit 3: Sources of Stress

In 1996, the Douglas School District began rearing frogs at several constructed, small wetland sites on school grounds. The project "Viva la Rana!" was successful in breeding and rearing frogs, some of which were translocated to San Bernardino NWR facilities (Biology 150, Douglas High School 1998). In 2003, the project was terminated and most of the ponds closed. Frogs were moved to the San Bernardino NWR, although some may remain at a large outdoor pond at Douglas High School.

In 2004, a Safe Harbor Agreement was developed by USFWS and the Malpai Borderlands Group. The agreement provides a framework for future frog conservation efforts with landowners in the one million acre Malpai Borderlands. Landowners can sign onto the program through a certificate of inclusion. By signing on, landowners receive a regulatory exemption for incidental take of Chiricahua leopard frogs that are established or colonize their properties after the date of inclusion. The agreement provides landowners who wish to participate in Chiricahua leopard frog recovery a regulatory assurance that they can participate without fear of liability. In 2005, the Magoffin Ranch signed a certificate of inclusion and is now participating in the agreement.

Management Areas

Five MAs have been defined for RU 3 (Figure B3). All but the Chiricahua Mountains MAs are known to have extant populations of Chiricahua leopard frogs. Frogs were present in the Chiricahuas until very recently, and may still occur in Rucker Canyon (Southern Chiricahua Mountains MA), near Portal (Northern Chiricahua Mountains MA), or elsewhere.

Northern Chiricahua Mountains MA (potential for metapopulation and buffer). Includes Ash Creek of Sulphur Springs Valley Area HU (only portions of this HU in the Chiricahua Mountains above 5,500 feet elevation), Wilcox Playa HU (only portions of this HU in the Chiricahua Mountains above 5,500 feet elevation), East Whitetail Creek-San Simon River (only portions of this HU in the Chiricahua Mountains above 5,000 feet elevation), and Cave Creek-San Simon River HU (only portions of this HU in the Chiricahua Mountains above 5,000 feet elevation). Chiricahua leopard frogs may still exist in the later HU.

Southern Chiricahua Mountains MA (potential for metapopulation and buffer). Includes the Whitewater Draw Headwaters HU (only portions of this HU in the Chiricahua Mountains above 5,500 feet elevation) and San Simon River Headwaters HU (only portions of this HU in the Chiricahua Mountains above 5,500 feet elevation). Chiricahua leopard frogs may still exist in Rucker Canyon.

Swisshelm Mountains MA (potential for metapopulation and buffer). Includes Leslie Creek-Whitewater Draw HU (only portions of this HU in the Swisshelm Mountains above 4,500 feet elevation). Included are lands at Leslie Canyon NWR that are occupied by Chiricahua leopard frogs.

Peloncillo Mountains / Animas and San Bernardino Valleys MA (potential for metapopulation [SBV], isolated population [Peloncillos and Animas], and buffer).

Upper San Bernardino Valley HU (only this HU above 4,500 feet elevation) and all populations on the San Bernardino National Wildlife Refuge and in the vicinity of Rosewood Tank, San Simon River Headwaters HU (only portions of this HU in the Peloncillo Mountains or above 4,700 feet elevation) and Lower San Bernardino Valley HU (all). Also included are adjacent lands in New Mexico and Sonora with extant populations and good potential for successful recovery. Additional opportunities may exist for recovery projects in the Sierra San Luis complex in northeastern Sonora and northwestern Chihuahua.

Animas Mountains/Playas Valley MA (potential for metapopulation, isolated population, and buffer). This MA does not follow HU boundaries, but instead encompasses historically occupied habitat and one or two currently extant populations on the eastern and southern slopes of the Animas Mountains, south to the base of the Sierra San Luis, and east into the Playas Valley.

Ajos-Bavispe East MA (potential for metapopulation, isolated population, and buffer). This MA follows the boundaries of the fracciones of the Ajos-Bavispe Forest Reserve and Wildlife Refuge, including portions of the Sierras el Tigre and la Madera, and Pilares de Teras, de Nacozari, and San Diego. As discussed above, the potential for Chiricahua leopard frogs to occur in these ranges is unclear; however, their protected status warrants consideration as an MA.

RECOVERY UNIT 4: PINALENO-GALIURO-DRAGOON MOUNTAINS

Environmental Setting

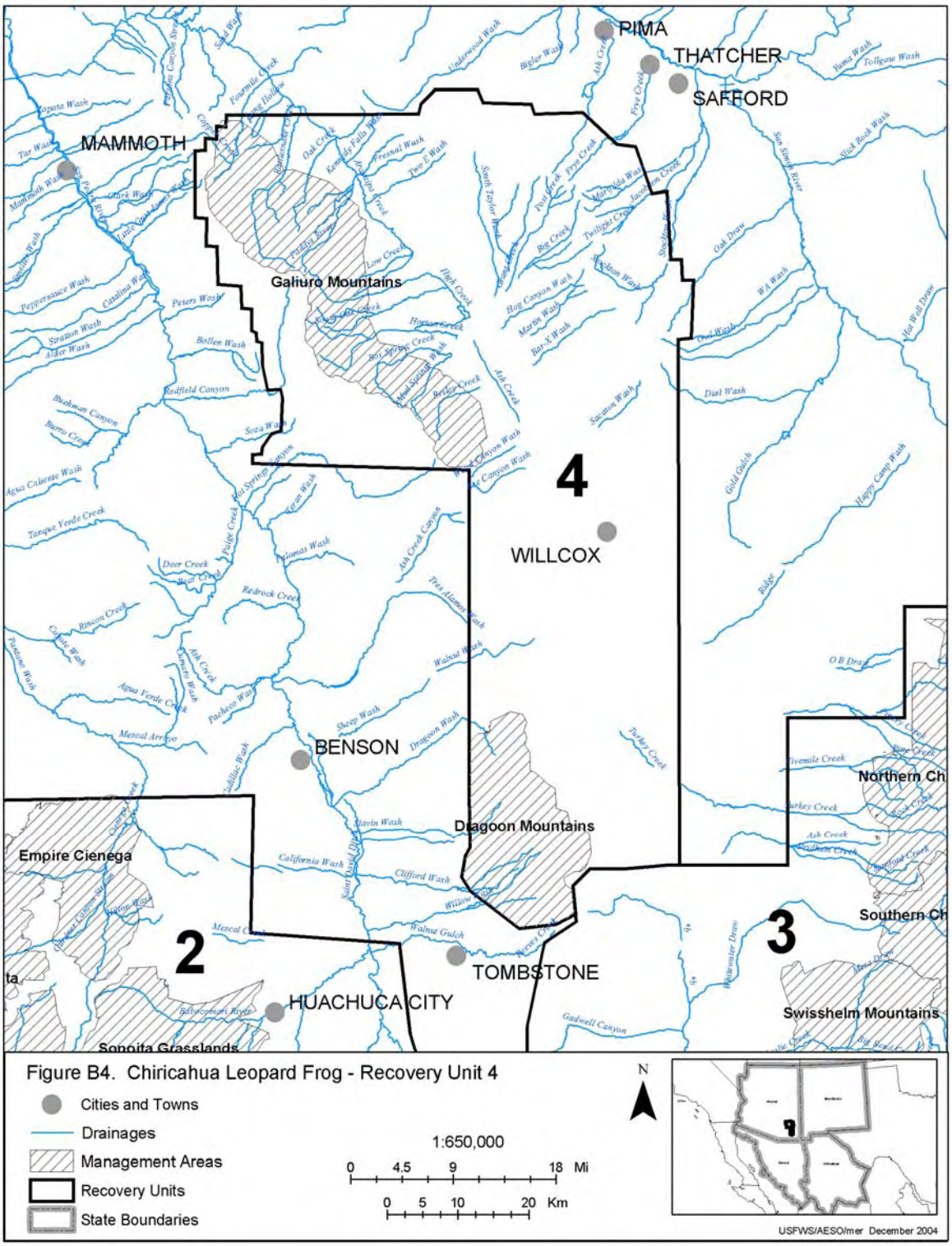
Recovery Unit 4 straddles Interstate 10 in Cochise and Graham counties, Arizona (Figure B4). To the south of I10, the RU includes portions of the Dragoon Mountains and Sulphur Springs Valley. To the north of I10, are the Little Dragoon, Winchester, and Galiuro mountains on the west, and the Pinaleno Mountains in the northeast. The Sulphur Springs Valley continues to the north between the Galiuro and Pinaleno mountains. Drainages in that valley run towards the Willcox Playa south of Willcox. North of Bonita and Hooker Cienega, drainages flow northwest into Aravaipa Creek. Elevations range from about 3,700 feet south of Klondyke to 10,720 atop Mount Graham in the Pinaleno Mountains. The highest peak in the Galiuro Mountains is Bassett Peak at 7,663 feet. In the Dragon Mountains, the highest point is Mount Glen at 7,519 feet.

Vegetation communities are characterized primarily by semi-desert grasslands in the valleys and Madrean evergreen woodlands in the Dragoon, Little Dragoon, Winchester, Galiuro, and lower elevations of the Pinaleno Mountains. At higher elevations in the Galiuro and Pinaleno mountains are stands of petran montane conifer forest. At the highest elevations in the Pinaleno Mountains are forests of Engelmann spruce, corkbark fir, Douglas fir, white fir, aspen, and other components of petran subalpine conifer forest. A small area of plains grassland is present in the Muleshoe area on the western slope of the Galiuro Mountains.

Due to a long history of grazing that removed fine fuels and fire suppression, woody fuel loads have increased in the petran montane conifer forest of the Pinaleno Mountains to the point that much of the mountain is at risk from catastrophic fire. In April 1996, the Clark Peak fire burned 6,716 acres in the Pinalenos. These conditions have been exacerbated by recent drought and insect infestations, including bark beetles, moth caterpillars, and a non-native aphid that has killed most of the Engelmann spruce in the subalpine forest in recent years. This subalpine forest is typically mesic, and historically has not supported the frequent ground fires characteristic of lower elevation forest types. The fire return interval is estimated at 300-400 years in the subalpine forest, and the last significant burn was a stand-replacing fire in 1685 (Grissino-Mayer *et al.* 1995). During summer of 2004, the Nuttall Complex fires burned nearly 30,000 acres in the Pinaleno Mountains, including portions of subalpine forest where trees had been killed by insects and drought. The Coronado National Forest has been planning and conducting fuel reduction projects in the Pinaleno Mountains over the last decade. Fuel reduction projects have been completed on 8,200 acres thus far, and another 15,300 acres are in the planning process. Fuel loads and risk of catastrophic fire are less in the Galiuro and other ranges in RU 4.

Chiricahua Leopard Frog Populations

Chiricahua leopard frogs are known historically from the Dragoon and Galiuro mountains, the Sulphur Springs Valley both north and south of Interstate 10, from near Bonita, and from just northeast of the Pinaleno Mountains. There are no records from the Little Dragoon, Winchester,



or Pinaleno mountains. Records from northeast of the Pinaleno Mountains and from near Bonita suggest they may have occurred, or may still occur, in some of the canyons in the Pinaleno Mountains. Nickerson and Mays (1970) reported that leopard frogs (*Rana pipiens* complex)

were common in all areas of permanent water, on all sides of the mountain below 4,600 feet. However, recent surveys there failed to find leopard frogs (L.L.C. Jones, pers. comm. 2004).

In the 1990s, numerous stock tank populations of Chiricahua leopard frogs were discovered in the Galiuro Mountains. These probably formed one or more metapopulations. However, surveys in 2002-'03 at 24 of 27 historical localities found only two extant populations (Jones and Sredl 2004), and one of those was eliminated in 2004 or '05. Reasons for the decline are unknown, but likely included drought, particularly during 2002, when many stock tanks in southeastern Arizona dried up. Chytridiomycosis is known from lowland leopard frogs in Aravaipa Canyon, but has not been found in Chiricahua leopard frogs from this RU.

A similar contemporaneous decline has also taken place in the Dragoon Mountains. Similar to the Galiuros, in the 1990s the Dragoon's supported ten small populations, some of which were probably part of one or more metapopulations, mostly in the southern portion of the mountain range. Today we know of only one small population, which occurs at a flooded mine adit. Again, the reason for the decline is unknown, but because many of the populations were located at stock tanks or small springs, drought likely eliminated many of them. Historically, most populations in RU 4 have inhabited livestock tanks; however, the remaining populations in the Galiuros are in a stream that is probably somewhat buffered against drought relative to stock tanks. As late as the 1980s, Chiricahua leopard frogs were found at an agricultural sump in the Sulphur Springs Valley south of Interstate 10.

Current Land Uses and Management

The northwestern portion of RU 4 is located within the Muleshoe Ranch Cooperative Management Area (CMA), largely encompassing the Galiuro Mountains. These 55,000 acres of mountainous terrain and canyons are jointly owned and managed by The Nature Conservancy, the Coronado National Forest, and the BLM. The CMA comprises most of the watershed area for seven permanently flowing streams, including Hot Springs, Redfield, and Cherry Springs watersheds. Included within the planning boundary are Redfield Canyon Wilderness and Hot Springs Watershed Area of Critical Environmental Concern (ACEC), administered by BLM, and a portion of the Galiuro Wilderness, administered by the Coronado National Forest**.** Riparian Monitoring Zones have been designated within the CMA that are of special environmental concern because of their unique floral, faunal, and hydrological values. Activities permitted within these areas include hiking, low-impact camping, and horseback riding. The remainder of the Galiuro Mountains are almost entirely owned and managed by the Coronado National Forest.

The Pinaleno Mountains are administered by the Coronado National Forest. The Pinalenos are an important recreation area, and the Coronado provides 12 developed recreation sites, including numerous campgrounds located along the Swift Trail, the primary access route from Highway 191 south of Safford into the high country of the mountain range. Columbine, located at elevation 9,500 feet, is a small community of summer cabins. Riggs Lake is a popular destination for campers and trout fisherman.

The northwestern portion of the Winchester Mountains is administered by the Coronado National Forest; the remainder is primarily managed by the Arizona State Land Department.

Small parcels and BLM and private lands are present, as well. Access into this range is limited, and few surveys for ranid frogs have been completed there.

The Dragoon Mountains are known for their dramatic granite boulders on both sides of the range from east and west Stronghold Canyons southeast to Middlemarch Canyon Road. The majority of the range is owned and managed by the Coronado National Forest, although the southern end is owned by the Arizona State Land Department and private owners. A few small parcels of BLM lands occur in the southern end, as well. A developed campground at Cochise Stronghold is a popular recreational destination. Lands between the Winchester and Dragoon mountains and adjacent portions of the Sulphur Springs Valley are managed primarily by private owners and the Arizona State Land Department. Forest Service lands are managed in accordance with the 1986 Coronado National Forest Plan. BLM lands are managed under the 1991 Safford District RMP. Arizona State Land Department manages State Trust lands and resources to enhance value and optimize economic return for the Trust's beneficiaries, which are primarily schools from Kindergarten through High School. Recreation, livestock grazing, and farming are important economic activities in RU 4. Evidence of mining is common in the mountain ranges, but it is mostly historical in nature.

Threats

A History of Land Uses - Past and Current Threats

Historical land uses consisted primarily of ranching and grazing operations going back 150 years. In 1982, The Nature Conservancy purchased the Muleshoe Ranch and its grazing leases to protect and manage its riparian areas and associated aquatic, plant, and animal communities. The Conservancy entered into a cooperative agreement with the BLM and the U.S. Forest Service to form the CMA in 1988. This enabled the partners to make decisions across property boundaries and manage the area as one unit. An Ecosystem Management Plan was drafted with a planning team that consisted of Conservancy scientists and site managers as well as staff from many State and Federal agencies, conservation organizations, ranchers, and neighbors. This plan focuses on managing for ecological processes and restoration of these processes instead of managing specifically for consumptive use.

The southern portion of the region was occupied almost exclusively by Chiricahua Apache Indians from the late 17th century through the 19th century. When Europeans first came through this valley late in the 1800s there was no free standing water except for short periods after summer thunderstorms and right at Sulphur Spring. Consequently this region was also avoided by the Spanish explorers and missionaries and later by Mexican and American prospectors and setters (Meinzer and Kelton 1913).

In 1876, the Chiricahua Apaches were moved to San Carlos Reservation, the Chiricahua Reservation was dissolved, and the valley began to become inhabited by miners and cattlemen. Early surveyors reported that water was plentiful at depths of only 10 feet. Mining became active in the late 1870s as silver was discovered at Shieffelin's "Tombstone", to west of the

Stresses – Altered Key Ecological Attributes	Severity	Scope	Stress
Extraordinary Predation	Very High	Medium	Medium
Infectious Disease	High	Very High	High
Aquatic patch degradation	High	High	High
Aquatic patch loss	Very High	High	High
Contaminants	Medium	Low	Low
Reduced connectivity	High	High	High

Table B7: Recovery Unit 4: Viability Summary

Dragoon Mountains. In 1880 the Copper Queen Mine was established with the first smelter being blown in at the town of Bisbee. Timber was harvested from local mountain ranges to fuel the smelter. During this same time cattle ranching increased substantially. Also in 1880, the southern Pacific Railroad crossed just north of "Playa de las Pimas" as C. C. Parry, part of Emory's Mexican Boundary Survey had named it in 1855. The town of Willcox became established there as a local supply depot, water stop, and shipping point for cattle and the playa became known as the Willcox Playa.

The earthquake of 1887 may have had an effect on the water resources of the valley. However, there is disagreement between authors on this subject. It was nonetheless a time of dramatic vegetation change. The 1887 earthquake caused the tops of all the mountain ranges surrounding the valley to be burned off, followed only months later by record-breaking rainfall events. This was followed by the drought of 1891 through 1893. The combined effects resulted in massive erosion and substantial changes to nearly all the plant communities in Cochise County.

Through the late 1800s and up into the mid 1900s several railroad lines were built and abandoned throughout the valley. This interrupted hydrological function of many of the drainage ways, causing deep gullying. As highways were raised and surfaced to become all weather roads, negative results in hydrological function were the same.

Irrigated agriculture peaked in the late 1950s and early 1960s as the groundwater level started to subside. In 1974 an Irrigation Non Expansion Area was established, stopping any new irrigated farm ground from being brought into production. Only those acres irrigated between 1974 and 1978 retained the water rights to continue farming. This resulted in thousands of acres of cropland being abandoned. By the late 1980s the mines in Bisbee had shut down and the smelter in Douglas was taken out of production. The new millennium has brought with it an increasing amount of farming once again with a new interest being shown by many landowners in "farming wildlife habitat". Livestock grazing is still a major influence in the valley.

Threats Assessment: 2004-2014

Tables B7 and B8 display the results of the threat assessment for this RU. Infectious disease (chytridiomycosis), aquatic habitat degradation and loss, and reduced connectivity are the most important stresses in this RU. Beyond its presence in Aravaipa Canyon, the current presence and

distribution of chytridiomycosis in RU 4 is unknown, but it poses a significant threat because of the metapopulation structure of recent populations in the Galiuro and Dragoon mountains, and current limitation of the species to very few sites.

Catastrophic fire, drought, and hydrologic alterations are the most important sources of aquatic habitat degradation and loss. Conditions in the Pinaleno Mountains are particularly ripe for catastrophic fire, although such events could also occur in the Galiuro or Dragoon mountains and threaten remaining extant frog populations in the RU. Drought was apparently a factor in the recent decimation of the metapopulation in the Dragoon Mountains, and likely contributed to the contemporaneous decline in the Galiuro Mountains. Hydrologic alterations such as small dams have altered habitats and enhanced conditions for non-native predators. Drought, and to a lesser degree, catastrophic fire are the most important sources of stress regarding reduced connectivity. Metapopulation structure is very important in maintaining local populations in the RU, because most of the available habitats are stock tanks or other small habitat patches that are subject to drying, loss due to fire (siltation or ash flow), and other disastrous events. Extraordinary predation is less of a threat in this RU as compared to others, but is still considered a moderate threat. Contaminants are a low threat in RU 4.

Past or Ongoing Chiricahua Leopard Frog Conservation

Although the Galiuro and Dragoon mountains have been surveyed relatively well over the last decade or more, no conservation efforts targeting Chiricahua leopard frogs have occurred in this RU. In 2004, USFWS, AGFD, and Coronado National Forest biologists met to discuss the potential for reestablishing populations in the Dragoon Mountains. However, to date, no further action has been taken on this potential project.

Management Areas

Two MAs have been identified in RU 4. These areas encompass portions of the Galiuro and Dragoon mountains that in the recent past have supported numerous, mostly stock tank, populations of Chiricahua leopard frogs. The species is still extant in both MAs, but status is tenuous because each MA support only one population.

Dragoon Mountains MA (potential for metapopulation and buffer). Includes the Wilcox Playa HU (only portions of this HU in the Dragoon Mountains above 4,700 feet elevation) and the Clifford Wash-Upper San Pedro River HU (only portions of this HU in the Dragoon Mountains above 4,700 feet elevation). Includes an extant population and area that contained a metapopulation until recently.

Galiuro Mountains MA (potential for metapopulation, isolated population [Peach Tree Tank], and buffer). Includes the Lower Aravaipa HU (only the portions of this HU in the Galiuro Mountains above 4,700 feet elevation), Upper Aravaipa HU (only portions of this HU in the Galiuro Mountains above 4,700 feet elevation), and Wilcox Playa HU (only portions of this HU in the Galiuro Mountains above 4,700 feet elevation). Includes the only extant population in this region and an area that supported a metapopulation until recently.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	Medium	Medium				Low	Medium
	Irreversibility	High	High				High	
	Override							
	Source	Medium	Medium				Medium	
	Combined Rank	Low	Medium				Medium	
Non-native fishes	Contribution	High					Low	Low
	Irreversibility	Medium					Medium	
	Override							
	Source	Medium					Low	
	Combined Rank	Low					Low	
Crayfish	Contribution	Low		Low	Low		Low	High
	Irreversibility	Very High		Very High	Very High		Very High	
	Override							
	Source	Medium		Medium	Medium		Medium	
	Combined Rank	Very High		Medium	Medium		Medium	

Table B8: Recovery Unit 4: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Non-native tiger salamander	Contribution	Low	Low					Medium
	Irreversibility	High	High					
	Override							
	Source	Medium	Medium					
	Combined Rank	Low	Medium					
Chytrid fungus	Contribution		Very High					High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		High					
Dirt stock Tank Manage-ment	Contribution	Medium		High	Medium		Medium	Medium
	Irreversibility	Low		Low	Low		Low	
	Override							
	Source	Low		Medium	Low		Low	
	Combined Rank	Low		Medium	Low		Low	
Poor Grazing Practices	Contribution			Low		Medium	Low	Low
	Irreversibility			Medium		Low	Low	
	Override							
	Source			Low		Low	Low	
	Combined Rank			Low		Low	Low	

Table B8: Recovery Unit 4: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution	Low	Low	High	High	High	Medium	High
	Irreversibility	Low	Low	High	High	Low	High	
	Override							
	Source	Low	Low	High	High	Medium	Medium	
	Combined Rank	Low	Low	High	High	Low	Medium	
Drought	Contribution			Very High	Very High		Very High	Very High
	Irreversibility			High	High		High	
	Override							
	Source			Very High	Very High		Very High	
	Combined Rank			High	High		High	
Hydrologic Alteration	Contribution	Medium		Low	Medium		Low	Medium
	Irreversibility	High		High	High		High	
	Override							
	Source	Medium		Medium	Medium		Medium	
	Combined Rank	Low		Medium	Medium		Medium	
Recreation	Contribution	Low	Low	Low				Low
	Irreversibility	High	Medium	Medium				
	Override							
	Source	Medium	Low	Low				
	Combined Rank	Low	Low	Low				

Table B8: Recovery Unit 4: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Surface Disturbance	Contribution			Low	Low	Low		Low
	Irreversibility			Low	High	High		
	Override							
	Source			Medium	Medium			
	Combined Rank			Low	Low			
Smelter Emissions	Contribution					Low		Low
	Irreversibility					High		
	Override							
	Source					Medium		
	Combined Rank					Low		
Iridovirus	Contribution		Low					Low
	Irreversibility		High					
	Override							
	Source		Very High					
	Combined Rank		Medium					

Table B8: Recovery Unit 4: Sources of Stress

RECOVERY UNIT 5: MOGOLLON RIM-VERDE RIVER

Environmental Setting

Recovery unit 5 lies along the Mogollon Rim in Arizona, including mostly forested lands both above and below the Rim (Figure B5). On the west, it is bordered by the Verde River southeast of Camp Verde. To the north the boundary is roughly along the interface between Plains grasslands of the Colorado Plateau and the pinyon-juniper communities characteristic of the lower drainages into the Little Colorado River. On the east, RU 5 terminates at the border of RU 6, where elevations rise into the White Mountains. The boundary on the south is based roughly on where elevations drop below about 4,000 feet, which corresponds to the presumed lower limit of the frog's distribution in this RU (see Table E1 of Appendix E). Above the Mogollon Rim, most drainages flow north or northeast into East Clear Creek, Chevelon Creek, and other tributaries of the Little Colorado River. Below the Mogollon Rim, Fossil Creek, East Verde River, West Clear Creek, and others drain into the Verde River. From west to east, Tonto, Spring, Cherry, Canyon, Cibecue, and Carrizo creeks, and the White and lower Black rivers flow into the Salt River in RU 5. This RU drops south of the Salt River on the San Carlos Apache Reservation into the upper reaches of Ash and Bonita creeks, which flow into the Gila River.

Both above and below the Mogollon Rim, vegetation is characterized by petran montane conifer forests, which are dominated by Ponderosa at the lower elevations, mixed with Douglas fir, white fir, and aspen at the higher elevations. Below roughly 6,500 feet, Ponderosa pine gives way to pinyon-juniper forests, or less commonly, Plains grassland to the north, and to south, pinyon-juniper or interior chaparral to the south (Brown and Lowe 1980). Isolated stands of petran montane conifer forests occur on the higher peaks and range to the south of the continuous stands characteristic of the Mogollon Rim region.

Chiricahua Leopard Frog Populations

Historically, Chiricahua leopard frogs were widely-distributed both above and below the Mogollon Rim in RU 5, including records from the following major drainages: Fossil Creek, East Verde, West Clear Creek, Ellison Creek, Tonto Creek, Canyon Creek, and Cherry Creek, among others. However, Chiricahua leopard frogs have not been found in the Sierra Anchas or Mazatzals. Above the Mogollon Rim, the species occurred in the East Clear Creek and Chevelon Creek drainages. Today, the species is known only from livestock tanks in the Buckskin Hills area of the Coconino National Forest (Fossil Creek drainage) and the Cherry and Crouch creek area near Young on the Tonto National Forest. Recent reports of frogs from Ellison Creek suggest the species may still be extant there, as well. Many areas have not been surveyed, or have not been visited recently. The status of the species on Tribal lands is known only from historical localities; current status is unknown.

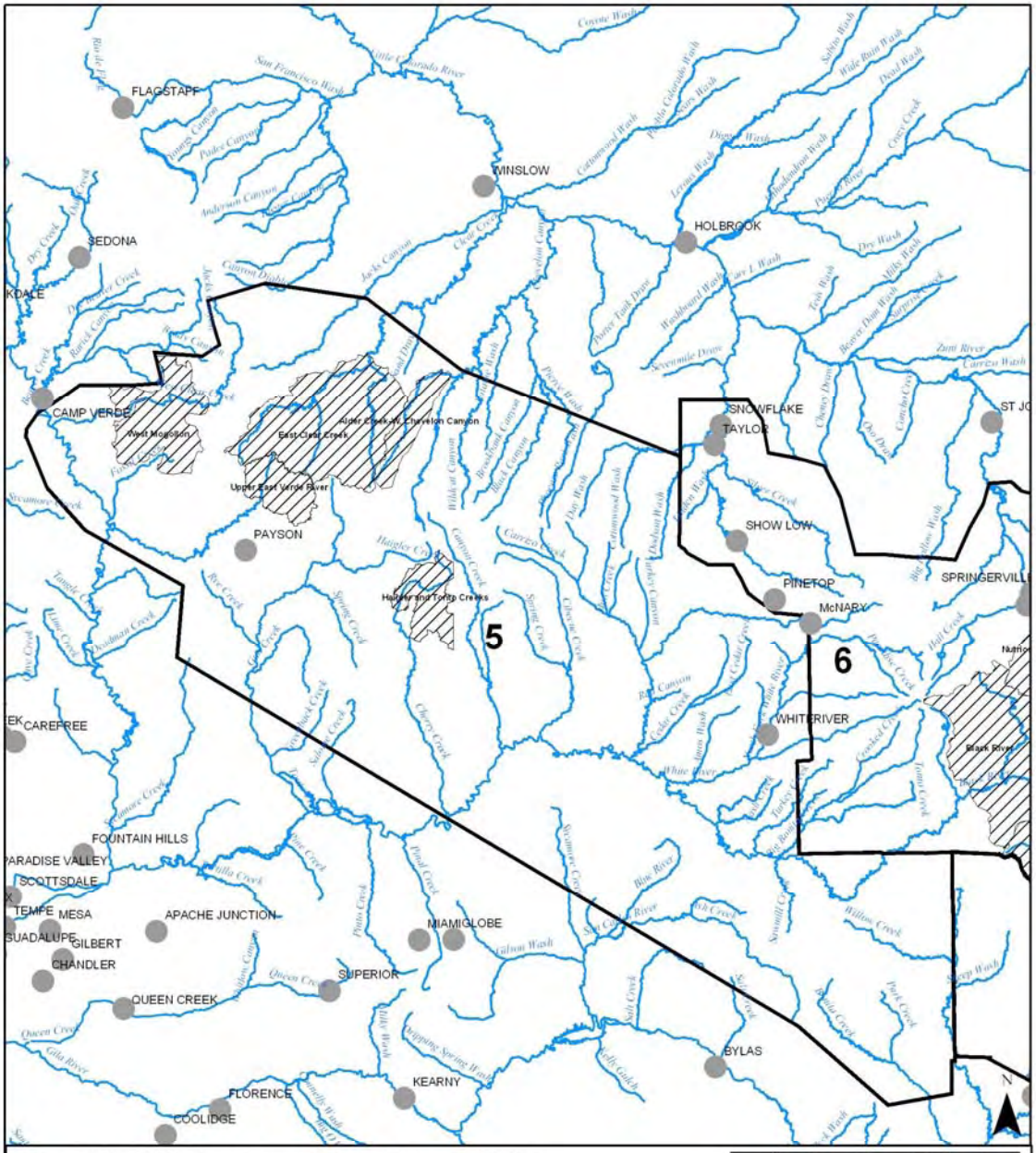


Figure B5. Chiricahua Leopard Frog - Recovery Unit 5

Cities and Towns
Drainages
Management Areas
Recovery Units
State Boundaries

1:1,279,412

0 4.5 9 18 Mi

0 15 30 60 Km

USFWS/AESO/mer December 2004

Current Land Uses and Management

RU 5 is primarily owned and managed by National Forests and the White Mountain Apache and San Carlos Apache Tribes. Lands in RU 5 on the Coconino National Forest are limited to areas east of the Verde River and north of Fossil Creek into the Buckskin Hills, and east and north to Long Lake, and then east to the forest boundary. RU 5 includes the Apache-Sitgreaves National Forests from its western boundary with the Coconino east to the boundary with RU 6 (west of Show Low and Silver Creek). RU 5 includes most of the northern half of Tonto National Forest east of the Verde River and the Gila County line.

RU 5 includes portions of the White Mountain Apache Reservation from the Tonto Forest boundary on the west to the Apache County line on the east, and from the Apache-Sitgreaves boundary on the north to the San Carlos Apache Tribal boundary (Salt River) on the south. Areas of the San Carlos Apache Reservation above 4,000 feet are included north of the Gila River and east to the southeastern boundary of the reservation.

National Forest lands are managed in accordance with Forest Plans, including the 1986 Tonto National Forest Plan, the 1987 Coconino National Forest Plan, and the 1987 Apache-Sitgreaves National Forests Plan, and subsequent amendments. These forests provide a number of multiple uses, such as recreation, livestock and timber production, protection of watersheds, cultural resources protection, wilderness and wild and scenic rivers, and other resources and public purposes.

The 1,834,781-acre San Carlos Apache Reservation is the sovereign lands of the San Carlos Apache Tribe. It is home to over 7,100 Apaches. Currently the largest employer on the reservation is the Tribal government, which operates many agencies there. In addition to government work, cattle ranching operations contribute approximately $1 million in annual livestock sales. The mining of peridot, a semiprecious stone, is also an important economic activity. The Reservation provides many recreational activities, including hunting, camping, fishing, and gaming at the Apache Gold Casino on Highway 70.

The White Mountain Apache Tribe has over 12,000 members located on nine major reservation communities on the White Mountain Apache (Fort Apache) Reservation. Whiteriver, the capital, is the largest community with over 2,500 residents. Major employment on the Reservation consists of a timber mill and re-manufacturing plant. Permits are available to hunt elk and other wildlife. Trout fishing is popular at the many lakes, streams, and rivers on the Reservation.

Private lands are few in RU 5, and are primarily located at and near major towns within the National Forests, such as Payson, Pine, Strawberry, Young, Heber-Overgaard, and Clay Springs.

Threats

A History of Land Uses - Past and Current Threats

White Mountain and San Carlos Apache Reservations

On February 1, 1877, the Fort Apache Reservation was established by executive order. The original Apache reservation extended roughly from the Gila River to the Mogollon Rim, and from Cherry Creek to the New Mexico border. In 1897, the land was divided into the White Mountain and San Carlos Apache Reservations.

Tonto National Forest

The Tonto National Forest was originally home to several prehistoric Indian groups who hunted and gathered wild plants in the Mazatzal Mountains and Sierra Ancha and along the Salt and Verde Rivers and their tributaries. The area was colonized more than a thousand years ago by a related group of people known today as the Hohokam. By about 600 years ago, the effects of several hundred years of droughts, floods, and warfare took their toll on the Hohokam and their neighbors and most of these people left the Tonto area, never to return.

After establishment of the San Carlos and White Mountain Apache Reservations, what is now the Tonto National Forest filled up rapidly with settlers. First came the miners and Mormon farmers, followed quickly by sheep and cattle ranchers. Mining remains a major industry around Globe and Miami and cattle ranching continues as a traditional economy and lifestyle, with many of the ranches on the Tonto remaining in the same families who originally homesteaded the area in the 1870s. The Tonto Forest was created in 1905 to protect the watersheds of the Salt and Verde rivers and the reservoirs, such as Roosevelt Lake. This continues to be a central management focus of the Tonto, while the reservoirs built along these rivers have created recreational opportunities for Arizonans. Recovery implementation in this area will need to consider water management. Coordination with Salt River Project and other water users will be necessary when considering water needs for recovery efforts.

Alford (1993) and Croxen (1926) described the history of livestock grazing on the Tonto National Forest. Cattle were moved into the area after the Civil War, and the Forest was fully stocked by 1890. By 1900, there were an estimated 1.5-2.0 million cattle grazing the Forest (in 1993, only 26,414 were grazed). Severe overgrazing occurred at that time, followed by a drought in 1904 and massive die offs of cattle. Watersheds and rangelands were damaged for many years to come. Beginning in the mid-1970s, major efforts began to reform grazing practices and improve range conditions. During recent drought, the Tonto removed cattle from most of the allotments on Forest to prevent resource damage.

Coconino and Apache-Sitgreaves National Forests

The Coconino National Forest was formed in 1908 from parts of the Black Mesa, Tonto, and Grand Canyon Forest Reserves and all of the San Francisco Mountains Forest Reserve. The Apache and the Sitgreaves National Forests were administratively combined in 1974 and are now managed as one unit from the Forest Supervisor's Office in Springerville. In the 1800s, the U.S. Army established a series of forts in New Mexico and Arizona. To supply these forts and settlements, a military road was built linking Sante Fe, New Mexico and Camp Verde near Prescott. Part of this road, called the General Crook Trail, runs almost the length of the Sitgreaves National Forest and in many places follows the brink of the Mogollon Rim.

The 2002 Rodeo-Chedeski Fire burned 460,000 acres of forested lands, including over 176,000 acres of the Tonto and Apache-Sitgreaves National Forests, with the remainder on the White Mountain Apache Reservation. Other recent fires, notably along and just below the Mogollon Rim, have also destroyed forests. Fuel loads are high due to fire-killed trees, as well as trees killed by bark beetles and drought. The primary effect of these fires on the Chiricahua leopard frog is ash flow, sedimentation, and scouring in drainages in and below burned areas. We are not aware of any extant populations of frogs that were impacted by recent fires. Efforts are underway to reduce fuel loads, particularly in the urban interface, and to restore watersheds.

Threats Assessment: 2004-2014

Tables B9 and B10 display the results of the threats assessment for RU 5. Extraordinary predation was ranked the greatest threat to the Chiricahua leopard frog in this RU. The most important contributors to that predation are non-native fishes and crayfish. American bullfrogs are not as widespread on the Mogollon Rim as they are in southeastern Arizona and southwestern New Mexico, and non-native salamanders are scarce or absent (a native tiger salamander is found on the Mogollon Rim). Infectious disease (chytridiomycosis) and aquatic habitat loss are the next most important stressors. The only documentation of chytridiomycosis from Chiricahua leopard frogs was from captives captured from the Buckskin

Hills area of the Coconino National Forest, but it is possible they contracted the disease in captivity. However, chorus frogs (*Pseudacris triserieta*) have been found infected nearby. Chiricahua leopard frogs may be more sensitive to the disease on the Mogollon Rim as compared to warmer areas in the southern portions of the species' range or where there are warm springs. Important contributors to aquatic habitat loss include non-native predators and the effects of catastrophic fire. Drought has recently resulted in the drying of several stock tanks in the Buckskin Hills and resulting loss of frog populations. Other stressors, including aquatic habitat degradation, contaminants, and reduced connectivity, are considered medium threats. Effects of catastrophic fire are the most important contributors to aquatic habitat degradation.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	Very High	Very High
Infectious Disease	High	High	High
Aquatic patch degradation	Medium	Medium	Medium
Aquatic patch loss	Very High	High	High
Contaminants	Medium	Medium	Low[1]
Reduced connectivity	High	Medium	Medium

Table B9: Recovery Unit 5: Viability Summary
[1]User override changed stress level from medium to low.

Contaminants result primarily from cattle feces, as well as ash flow and fire retardants associated with catastrophic fire and fire suppression. Non-native predators, effects of catastrophic fire, and drought all can act to remove stepping-stone habitats, thus reducing connectivity among populations.

Our knowledge of stresses and sources of stress comes primarily from the National Forest lands in RU 5. The RU also contains significant acreages of tribal lands owned and managed by the White Mountain and San Carlos Apache Tribes. Stresses and sources of stress on these tribal lands are likely similar to those on the adjacent National Forests.

Past or Ongoing Chiricahua Leopard Frog Conservation

Considerable effort has been undertaken to reestablish and conserve Chiricahua leopard frogs in the Gentry and Crouch Creek areas of the Tonto National Forest near Young, and also in the Buckskin Hills. In 1998, Carroll Spring, in the headwaters of Crouch Creek, was renovated by building a pool just below the developed springhead. Forty captively-reared Chiricahua leopard frogs were released to the site by AGFD personal on October 27, 1998. Additional releases occurred at H-Y Tank and Cunningham Spring. The latter site was fenced to exclude elk and cattle, and to prevent associated riparian damage. These projects were supported by the Tonto National Forest, and the Phoenix Zoo reared the frogs. As of 2004, frogs have persisted at Carroll Spring, but disappeared from the other two sites. Frogs also occur at Bottle Spring, Gentry Creek, and possibly Crouch Creek. Plans have been developed to renovate and potentially reestablish frogs at several sites in the area.

In the Buckskin Hills, Chiricahua leopard frogs were observed at 15 different livestock tanks during the 1990s and early 2000s. However, invasion by non-native predators and drought reduced the number of occupied tanks dramatically by the end of 2002. In 2002, Chiricahua leopard frogs were salvaged from Walt's Tank as it was going dry and were transferred to the Arizona-Sonora Desert Museum for temporary holding. The tank was renovated and refilled, and the frogs were repatriated in 2003. Water was pumped to Sycamore Basin Tank to prevent it from drying and to conserve the frog population there. Five tanks in the area have been recently removated, which is expected to provide additional habitat for the frogs. Currently only a small number of frogs occupy two tanks. In September 2005, four frogs were salvaged and taken to the Phoenix Zoo for captive breeding in the hope of creating a source of animals for reestablishment projects. Crayfish control via trapping was investigated in the Buckskin Hills by AGFD.

Management Areas

Five MAs have been designated in RU 5 (Figure B5). These MAs include areas with extant populations (West Mogollon and Gentry Creek MAs), as well as areas with high potential for reestablishing and managing for Chiricahua leopard frogs. Additional areas may be identified on Tribal lands through discussions and agreements with the White Mountain and San Carlos Apache Tribes.

West Mogollon MA (potential for metapopulation, isolated population and buffer). Includes Fossil Creek-Lower Verde River HU (only portions of this HU above 5,500 feet elevation or in Boulder Creek and Doriens Defeat canyons above 4,800 feet elevation) and West Clear Creek HU (only portions of this HU above 5,200 feet and below 6,500 feet elevation).

East Clear MA (potential for metapopulation and buffer). Includes the entire Upper Clear Creek HU.

Alder Creek-West Chevelon Canyon MA (potential for metapopulation and buffer). Includes Upper Chevelon Creek HU (only portions of this HU upstream of West Chevelon Creek-Chevelon Creek confluence).

Upper East Verde River MA (potential for metapopulation and buffer). Includes Upper East Verde River (all, 1506020350E) and Ellison Creek (all, 15060203050E).

Gentry Creek MA (potential for metapopulation and buffer). Includes Gentry Creek (only portions of this HU in Tonto National Forest, 15060103020E) and Crouch Creek (only portions of this HU in Tonto National Forest, 15060103040E).

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	Medium	Low		Very High		Medium	High
	Irreversibility	High	High		High		High	
	Override							
	Source	Medium	Medium		Very High		Medium	
	Combined Rank	High	Medium		High		Low	
Non-native fishes	Contribution	Very High			Very High		High	Very High
	Irreversibility	High			High		High	
	Override							
	Source	Very High			Very High		High	
	Combined Rank	Very High			High		Medium	
Crayfish	Contribution	Very High		Low	Very High		Medium	Very High
	Irreversibility	Very High		Very High	Very High		Very High	
	Override							
	Source	Very High		Medium	Very High		High	
	Combined Rank	Very High		Very High	High		Medium	

Table B10: Recovery Unit 5: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Dams and Reservoirs (exclusive of stock tanks)	Contribution	Very High		High	Medium		Medium	Very High
	Irreversibility	Very High		Very High	Very High		Very High	
	Override							
	Source	Very High		High	High		High	
	Combined Rank	Very High		Medium	High		Medium	
Chytrid fungus	Contribution		Very High					High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		High					
Dirt stock Tank Manage-ment	Contribution		Low	Medium	Low		Medium	Low
	Irreversibility		Low	Medium	Medium		Medium	
	Override							
	Source		Low	Medium	Low		Medium	
	Combined Rank		Low	Low	Low		Low	
Ungulate Grazing	Contribution		Low	High	Low	High	Medium	Medium
	Irreversibility		Very High	High	High	High	High	
	Override							
	Source		Medium	High	Medium	High	Medium	
	Combined Rank		Medium	Medium	Medium	Low	Low	

Table B10: Recovery Unit 5: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution		Low	Very High	Very High	High	High	High
	Irreversibility		High	Very High	Very High	Very High	Very High	
	Override							
	Source		Medium	Very High	Very High	High	High	
	Combined Rank		Medium	Medium	High	Low	Medium	
Drought	Contribution			High	High		High	High
	Irreversibility			High	High		Very High	
	Override							
	Source			High	High		High	
	Combined Rank			Medium	High		Medium	
Surface water diversion	Contribution			Medium	Medium		Low	High
	Irreversibility			Very High	Very High		Very High	
	Override							
	Source			High	High		Medium	
	Combined Rank			Medium	High		Low	
Recreation	Contribution	Medium	Low	Medium		Low		High
	Irreversibility	High	Very High	Medium		Medium		
	Override							
	Source	Medium	Medium	Medium		Low		
	Combined Rank	High	Medium	Low		Low		

Table B10: Recovery Unit 5: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Surface Disturbance	Contribution			Medium	Low	Low	Low	Medium
	Irreversibility			High	High	High	Low	
	Override							
	Source			Medium	Medium	Medium	Low	
	Combined Rank			Medium	Medium	Medium	Low	
Excessive groundwater withdrawal	Contribution			Medium	Medium		Low	High
	Irreversibility			Very High	Very High		Very High	
	Override							
	Source			High	High		Medium	
	Combined Rank			Medium	High		Low	
Vegetation alteration	Contribution			Medium	Low	Low	Low	Medium
	Irreversibility			High	High	Medium	Low	
	Override							
	Source			Medium	Medium	Low	Low	
	Combined Rank			Medium	Medium	Low	Low	

Table B10: Recovery Unit 5: Sources of Stress

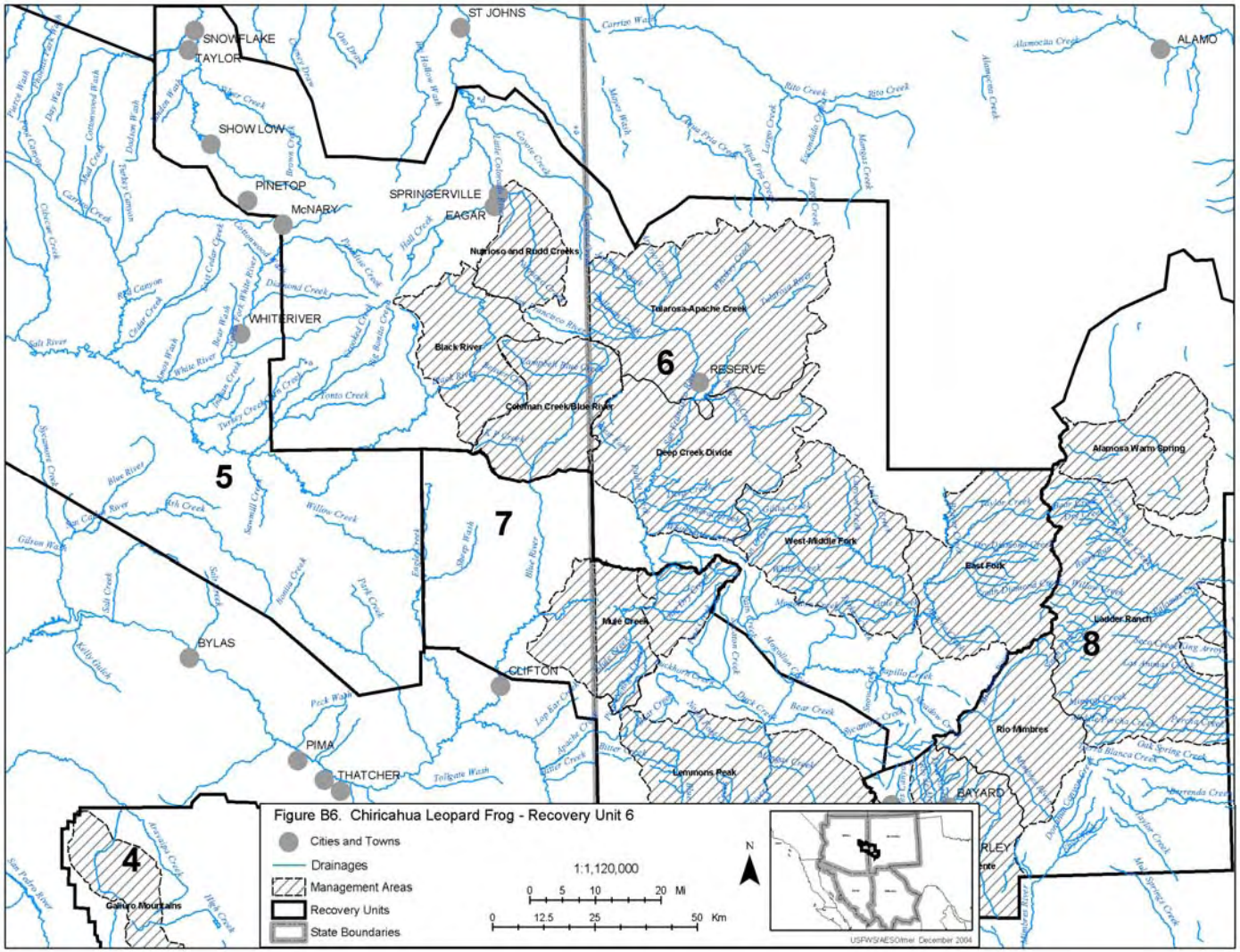
RECOVERY UNIT 6: MOGOLLON RIM-UPPER GILA

Environmental Setting

RU 6 contains the highest elevation and most mesic environments within the range of the Chiricahua leopard frog. Included are the White Mountains, the highest peak of which is the 11,403-foot Baldy Peak on the White Mountain Apache Reservation. The White Mountains contain headwaters of the Little Colorado, White, Black, Blue, and San Francisco rivers. In Arizona, RU 6 also extends northwest through the Show Low area to capture Silver Creek in the Little Colorado River drainage. In New Mexico, RU 6 includes the San Francisco and Tularosa rivers, the Gila National Forest, including the Gila Wilderness in the headwaters of the Gila River, southeast to the continental divide in the Black Mountains, and south to near Silver City (Figure B6). Elevations in New Mexico are frequently above 7,000 feet, and include many peaks above 9,000 feet, including the 10,895-foot Whitewater Baldy Peak in the Mogollon Mountains of the Gila Wilderness, which is the highest peak in the New Mexico portion of RU 6. Lands in the very northwestern portion of the RU in New Mexico drain into the Little Colorado River. Most of the remainder of the RU in New Mexico drains into the Gila River. The high country of RU 6 is characterized by forested landscapes with many meadows, lakes, streams, and rivers.

The predominant vegetation community in RU 6 is petran montane conifer forest, including Ponderosa pine and mixed conifer forest types. At the higher elevations in the White and Mogollon mountains are extensive stands of petran subapline conifer forest communities of Engelmann and blue spruce, subalpine fire, corkbark fir, and other high-elevation conifers. These forests are wet and cold, and receive from 25-39 inches of rainfall annually. Petran subalpine conifer forests also occur in scattered locations at high elevation outside of the White and Mogollon mountains. The ecotone between the subalpine and montane forest is often indistinct, but usually occurs in the range of 8,000-9,500 feet. Below the petran montane conifer forest, typically at elevations of 4,900-7,500 feet, are large areas of Great Basin conifer woodland, or pinyon-juniper. These woodlands occur as elevations drop off both above and below the Mogollon Rim, and in New Mexico, along the San Francisco and Tularosa rivers, and along the Gila River and its forks above Cliff (Brown 1982, Brown and Lowe 1980).

Large patches of subapline grasslands occur between the Mogollon Mountains and Elk Mountain in New Mexico, as well as in the White Mountains of Arizona, but also occur in smaller formations in park-like settings within forested areas. These grasslands or meadows are composed of bunch grasses and a variety of herbaceous plants. Plains grasslands occur near Springerville and elsewhere in the Little Colorado River drainage, in the headwaters of the Gila River, and on the western edge of the Plains of San Agustin. In the southern portions of RU 6 in New Mexico are small stands of semi-desert grasslands and Madrean evergreen woodlands; formations that are much more common in RUs 1-4 (Brown and Lowe 1980).


SNOWFLAKE
TAYLOR
SHOW LOW
PINETOP
McNARY
WHITERIVER
ST JOHNS
SPRINGERVILLE
EAGAR
ALAMO
BYLAS
CLIFTON
PIMA
THATCHER
RESERVE
BAYARD
RILEY
Nutrioso and Rudd Creeks
Tularosa-Apache Creek
Black River
Coleman Creek/Blue River
Deep Creek Divide
West-Middle Fork
East Fork
Alamosa Warm Spring
Ladder Ranch
Rio Nimbres
Mule Creek
Lemmons Peak
Galiuro Mountains
5
6
7
8
4
Figure B6. Chiricahua Leopard Frog - Recovery Unit 6
Cities and Towns
Drainages
Management Areas
Recovery Units
State Boundaries
1:1,120,000
0 5 10 20 MI
0 12.5 25 50 Km
N
USFWS/AESO/mer December 2004

Chiricahua Leopard Frog Populations

Historically, Chiricahua leopard frogs were well-distributed in this RU to elevation 8,890 feet. Historical records exist in Arizona for the White Mountains in the Black and White river drainages, Silver Creek near Snowflake, Nutrioso Creek, and in the headwaters of the Blue and San Francisco rivers. In New Mexico, Chiricahua leopard frogs are known from the San Francisco and Tularosa rivers; the West, Middle, and East forks of the Gila River; the Blue and Dry Blue rivers, and their tributaries. The frog historically occurred in creeks and rivers, lakes, bogs or cienegas, and livestock tanks. In Arizona, the frog is known today from the Black River headwaters, including Three Forks and a recent reestablishment site – Sierra Blanca Lake, with one other possible location in the Black River drainage and a few possible sightings in the upper Blue River area. In New Mexico, the species has been observed since 1998 in the West and Middle forks of the Gila River drainage, Tularosa and San Francisco river drainages, a tributary to Dry Blue Creek, and in livestock tanks in the Deep Creek Divide area.

Current Land Uses and Management

The majority of the lands in RU 6 are managed by the Forest Service, including the Apache-Sitgreaves National Forests in Arizona and the Gila National Forest in New Mexico. The Apache National Forest extends into the upper San Francisco and Tularosa rivers area, but that portion of the forest in New Mexico is administered by the Gila National Forest. The White Mountain Apache Reservation extends east through the White Mountains to about Baldy Peak and Mount Ord, and Reservation Lake, north past Highway 260, and south to the southern boundary of RU 6 in Arizona. In Arizona to the north of the National Forest are a checkerboard of private, Arizona State Land Department, and BLM parcels that is difficult to manage. The RU in New Mexico is nearly all National Forest, with the exception of relatively small acreages in the western end of the Plains of Augustin, near Windmills, and in towns and cities, which are predominantly private or State-owned. The BLM manages some parcels on the edge of the Forest northeast of Windmills.

The National Forest lands in New Mexico are managed in accordance with the 1986 Gila National Forest Plan. Forest lands in Arizona in RU 6 are managed pursuant to the 1987 Apache-Sitgreaves National Forest Plan. These plans prescribe multiple use management for recreation, wildlife, timber production, livestock production, wilderness values, and a variety of other uses. In 1998, the Forest Service and litigants, Forest Guardians of Santa Fe and the Center for Biological Diversity of Tucson agreed out-of-court to remove cattle from the upper watersheds of the Gila basin. Congress allocated approximately $400,000 for fencing along approximately 230 miles of streams and rivers in the Gila watershed in Arizona and New Mexico. Additional lawsuits have been filed by litigants regarding impacts to threatened and endangered species and associated compliance. The Gila National Forest is in the process of amending their standards and guidelines for riparian inventory and management.

See the Current Land Uses and Management in the narrative for RU 5, above, for a description of land management on the White Mountain Apache Reservation. In RU 6, the White Mountain Apache Tribe owns and operates one of the largest ski resorts in the Southwest, the Sunrise Ski

Resort in the White Mountains. A modern gambling casino is located at Hon-Dah (junction of Highways 260 and 73) east of Pinetop.

Arizona State Land Department manages State Trust lands and resources to enhance value and optimize economic return for the Trust's beneficiaries, which are primarily schools from Kindergarten through High School. New Mexico state lands are managed by the New Mexico State Land Office. The State Land Office is responsible for administering surface and subsurface lands for the beneficiaries of the State land trust. Each acre of land is designated to a specific beneficiary, with public schools receiving more than 90 percent of the acreage. The goals of the trust are to optimize revenues while protecting the health of the land for future generations. Livestock production is a primary use of State Trust lands in both the Arizona and New Mexico portions of RU 6.

BLM lands in Arizona are managed in accordance with the 1990 Phoenix District RMP. BLM lands in New Mexico are administered by the Socorro Field Office pursuant to the 1989 Socorro District Resource Management Plan.

Threats

A History of Land Uses - Past and Current Threats
Much of the following discussion on timber production and grazing is taken from Graham and Sisk (2002).

In the early 1880s, the Santa Fe Railroad's transcontinental railway was under construction through New Mexico and Arizona. By 1880, tracks were being laid west of Albuquerque and the railroad reached Needles, California on the Colorado River in 1883. The railroad ran north of RU 6 through Lupton, Winslow, and Flagstaff. The railroad made it easy for settlers to come to New Mexico and Arizona, but just as importantly, also allowed interstate commerce of livestock, minerals, and timber.

Logging began in the vast conifer forests of RU 6 in the 1880s with the harvest of railroad ties and other products for construction of the railroad. At first, only large, high-grade ponderosa pines were cut. However, soon increased volume was removed, sometimes reaching 70-80 percent of stands. Vast amounts of slash and other debris left on the forest floor caused much of what was left of these forests to burn in the late 1800s.

Beginning in the 1920s, new technology including chainsaws, bulldozers, and logging trucks allowed for further harvest in areas that had been inaccessible or otherwise not economical to harvest. In the 1930s, concern that snags contributed to the spread of lightening-caused wildfires led to the removal of many large snags by the Civilian Conservation Corps, further reducing the habitat quality of these forests for wildlife.

In the 1940s, 1950s, and 1960s dramatic increases in harvesting and road building occurred in the National Forests. Policies called for even-aged management of forests. To insure continued timber supplies until young trees could establish and grow to adequate size, harvests of large trees were reduced by distributing the cut to two or more entries. During this time, typical

harvests removed one-third to two-thirds of the available volume. At these residual stocking rates, stem density increased while tree size and age decreased.

Timber management practices on National Forests in the 1970s and 1980s continued to emphasize intensive, even-aged management, despite concerns of many resource professionals and an increasingly vociferous public that even-aged management negatively impacted visual quality, wildlife, riparian zones, and water quality. Harvests increased in mixed-conifer forests due to favorable markets for these tree species. In the 1970s new Federal regulations, such as the ESA, NEPA, and the National Forest Management Act began to constrain timber and other resource extraction activities on National Forests, and to emphasize to a greater degree sustained use and threatened and endangered species, and other forest resources. Harvest levels gradually increased through the 1950s and, under sustained-yield management, remained relatively flat through the 1980s. Harvests only began to decline in the 1990s after lawsuits from environmental organizations challenged most large timber sales based on recent regulations to protect a variety of forest resources.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	Very High	Very High
Infectious Disease	Very High	Very High	Very High
Aquatic patch degradation	High	High	High
Aquatic patch loss	Very High	High	High
Contaminants	Low	Medium	Low
Reduced connectivity	High	Medium	Medium

Table B11: Viability Summary for RU 6

The cattle and sheep industries also increased with the arrival of the railroad. By 1890, hundreds of thousands of cattle and large numbers of sheep were grazing on the Colorado Plateau. As a result of excessive stocking numbers, once rich grasslands were seriously degraded by 1900. By the early 1900s, overstocking of sheep on many middle-elevation mesas had brought forest regeneration to a halt. Fires became much less frequent, and when areas did burn, they burned catastrophically due to removal of fine fuels that had carried low-intensity ground fires and removed woody fuels and small trees.

By 1912, Theodore Rixon, one of the first foresters in the Southwest, found that “The mountains were denuded of their vegetative cover, forest reproduction was damaged or destroyed, the slopes were seamed with deep erosion gullies, and the water-conserving power of the drainage basins became seriously impaired” (Rogers 1963).

The Organic Act for the Forest Reserves was passed in 1897. It provided the authority to regulate livestock use, and in 1901 a permit system was implemented to regulate all grazing on Federal lands, partly in response to pleas from communities that were suffering from floods, soil loss and other impacts of unregulated grazing in the late 1800s. With the passage of environmental protection laws in the 1970s, efforts increased to manage livestock on the Gila and Apache-Sitgreaves National Forests. Lawsuits in the late 1990s and 2000s have precipitated further changes in grazing management. See Current Land Uses and Management for additional discussion.

Logging is mostly limited to thinning, forest restoration, salvage, and fire wood harvest on the National Forests. However, in 2003 Forest Guardians challenged the Gila National Forest on their Sheep Basin project, which would log mature trees on 3,800 acres, and is reportedly the first in a series of timber sales that would cut up to 90 million board feet and build 50 miles of roads. The project would occur in the Negrito Creek watershed.

Recent drought and insect infestations have caused tree death, particularly in Ponderosa and pinyon pine. These factors have fueled recent fires, including the 7,900 acre Three Forks Fire in June 2004, which burned near frog populations at Three Forks and Sierra Blanca Lake. Continuing drought would exacerbate tree death and increase the likelihood of additional catastrophic fires.

Threats Assessment: 2004-2014

Tables B11 and B12 display the results of the threats assessment for RU 6. The most important stresses in RU 6 are extraordinary predation and infectious disease (chytridiomycosis). Crayfish are the most important contributor to extraordinary predation. However, non-native fishes and American bullfrogs are also important. Non-native salamanders are not known from RU 6, and are not considered a threat. Chytridiomycosis has been documented in Chiricahua leopard frog declines in the New Mexico portion of the RU. Relatively high elevations and cold waters in this RU compared to most others may make the species more sensitive to chytridiomycosis. Aquatic habitat degradation and loss are the next important stresses. This RU is fairly mesic and may have more wetted areas than most of the RUs, but many are degraded or have been and are expected to be lost as frog habitat due to crayfish invasion, effects of catastrophic fire, surface water capture, and other factors. Connectivity is similarly affected as aquatic habitats are lost or become unsuitable as frog habitats (although reduced connectivity is only considered a moderate threat). The Three Forks Fire burned 7,900 acres near frog habitats in 2004, and additional fires are expected, particularly if drought continues. Contaminants are considered a low stressor in RU 6, although fire retardants used during fire suppression are a threat. Contributors include cattle feces, ash flow, and fire retardants associated with catastrophic fire and fire suppression.

Past or Ongoing Chiricahua Leopard Frog Conservation

Reestablishment of Chiricahua leopard frogs in RU 6 was first attempted at the AGFD's Sipes White Mountain Wildlife Area near Three Forks in Arizona. Tadpoles and metamorph frogs from a facility at Grand Canyon University in Phoenix, which originally were collected at Three Forks in 1991, and additional animals collected at Three Forks were released to Trinity Reservoir and a pond at Rudd Creek in early September 1996 by AGFD personnel. Mortality of tadpoles

was noted within hours of release, and was likely caused by low dissolved oxygen. Predation by tiger salamanders and crayfish may have eliminated metamorph frogs. No Chiricahua leopard frogs were seen at either site after October 1, 1997.

During 2000, Chiricahua leopard frogs originating from Three Forks and reared at the AGFD facility in Pinetop were established at Concho Bill, on the Apache-Sitgreaves National Forest, in the Black River drainage, Arizona. By 2001, it appeared the establishment project had failed, as no frogs were observed that year, and none have been detected since. Frogs were also released at the same time to Three Forks to augment that declining population. Although crayfish have invaded the pond where frogs primarily breed at Three Forks, the frogs have persisted there to date.

On May 28, 2004, 50 young Chiricahua leopard frogs and late stage tadpoles reared at the AGFD Pinetop facilities and originating from Three Forks were released to Sierra Blanca Lake along Boneyard Creek near Three Forks. The current status of that reestablished population is unknown. Sierra Blanca Lake is managed by The Nature Conservancy and the Apache-Sitgreaves National Forests.

Management Areas

The following seven MAs are designated in RU 6 (Figure B6):

Nutrioso and Rudd Creeks MA (potential for metapopulation and buffer). Includes all of the Nutrioso Creek HU.

Black River MA (potential for metapopulation and buffer). Includes all of the Upper Black River HU.

Coleman Creek / Blue River MA (potential for metapopulation and buffer). Includes all of the Upper Blue River HU in Arizona and Deep Creek HU in New Mexico.

Tularosa River/ Apache Creek MA (potential for metapopulation and buffer)
Based on New Mexico 10 digit HUs: and includes Apache HU (modified to include Patterson Lake), Upper Frisco HU, and Tularosa HU.

Deep Creek Divide MA (potential for metapopulation and buffer). Includes Pueblo HU, Middle Frisco HU, Negrito HU, and unnamed HU (1) just south of Middle Frisco and Negrito HUs.

West/Middle fork Gila MA (potential for metapopulation and buffer). Includes Gila Middle Fork HU and Gila West Fork HU.

East Fork MA (potential for metapopulation and buffer). Includes Gila East Fork HU, Black HU, Diamond HU, Hoyt HU, and Corduroy HU.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	High	Medium				Medium	Very High
	Irreversibility	High	High				High	
	Override							
	Source	High	Medium				Medium	
	Combined Rank	Very High	Medium				Low	
Non-native fishes	Contribution	High					High	Very High
	Irreversibility	High					High	
	Override							
	Source	High					High	
	Combined Rank	Very High					Medium	
Crayfish	Contribution	High		Medium			Medium	Very High
	Irreversibility	Very High		Very High			Very High	
	Override							
	Source	High		High			High	
	Combined Rank	Very High		High			Medium	

Table B12: Recovery Unit 6: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Hydrologic Alteration	Contribution	Medium		High			Medium	Very High
	Irreversibility	Very High		High			Very High	
	Override							
	Source	High		High			High	
	Combined Rank	Very High		High			Medium	
Chytrid fungus	Contribution		Very High					Very High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		High					
Dirt stock Tank Manage-ment	Contribution	Medium	Low	Low			Medium	Medium
	Irreversibility	Low	Low	Low			Medium	
	Override							
	Source	Low	Low	Low			Medium	
	Combined Rank	Medium	Medium	Low			Low	
Ungulate Grazing	Contribution			Medium	High	High	Medium	Medium
	Irreversibility			High	Medium	High	High	
	Override							
	Source			Medium	Medium	High	Medium	
	Combined Rank			Medium	Medium	Low	Low	

Table B12: Recovery Unit 6: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution		Low	High	Very High	High	High	Very High
	Irreversibility		High	High	Very High	High	High	
	Override							
	Source		Medium	High	Very High	High	High	
	Combined Rank		High	High	High	Low	Medium	
Recreation	Contribution	Medium	Low	Medium		Low		High
	Irreversibility	High	Very High	Medium		Medium		
	Override							
	Source	Medium	Medium	Medium		Low		
	Combined Rank	High	High	Medium		Low		

Table B12: Recovery Unit 6: Sources of Stress

RECOVERY UNIT 7: UPPER GILA-BLUE RIVER

Environmental Setting

RU 7 straddles the border between Arizona and New Mexico south of RU 6, and includes a portion of the Gila River and its watershed after it leaves the Gila Wilderness, the Blue River and major tributaries, such as Dry Blue Creek and Campbell Blue Creek, and a portion of the San Francisco River in Arizona (Figure B7). The Blue River and Mule Creek are major tributaries of the San Francisco River. Elevations range from about 4,000 feet on the southern edge of the RU to 8,035 feet in the Burro Mountains in the southeastern portion of the RU, and the 8,294 foot Maple Peak east of the Blue River on the Apache-Sitgreaves National Forests. The southeastern portion of the RU is topographically more similar to RUs 1-4 than 5 and 6, in that it is characterized by basins and ranges.

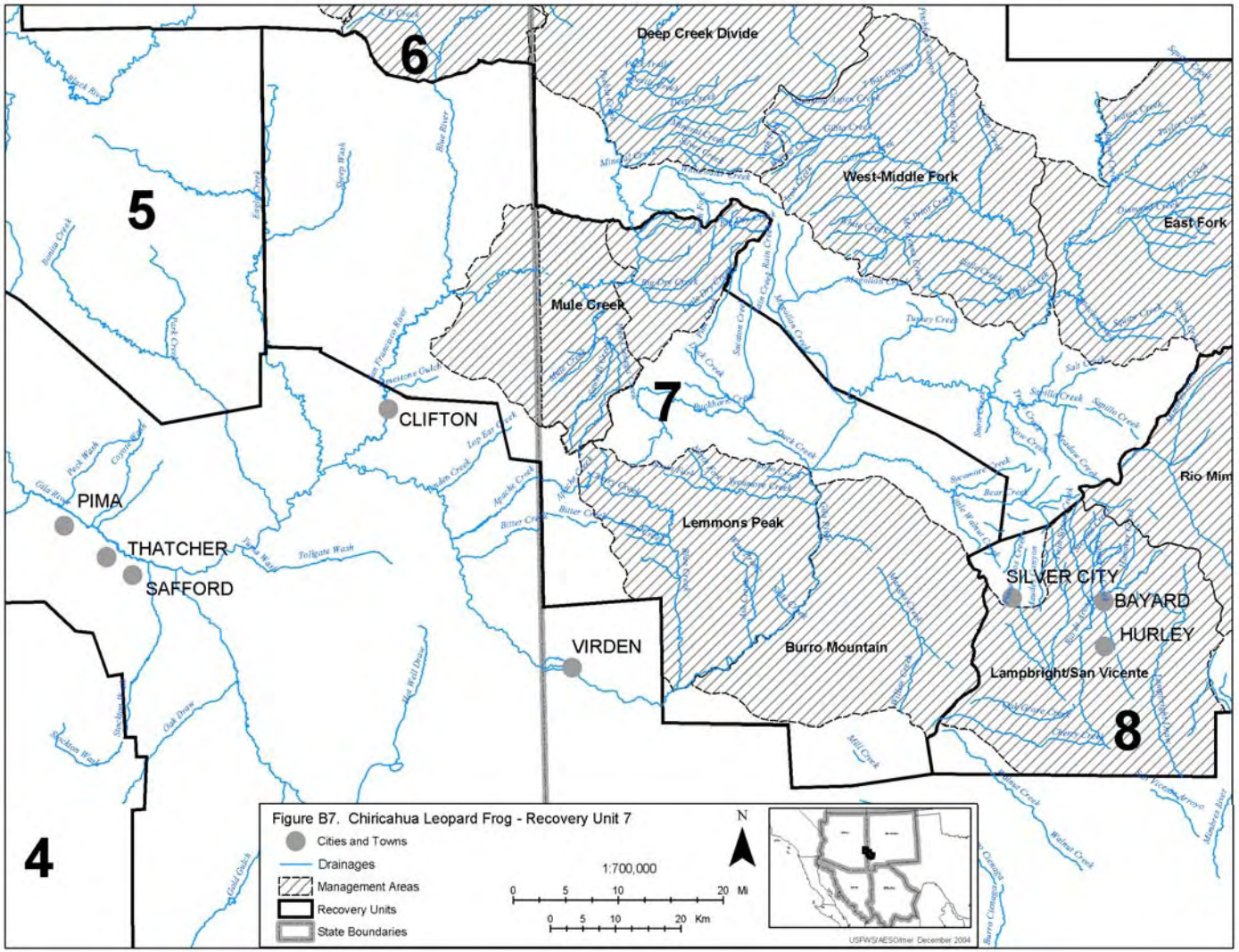
A variety of vegetation communities occur in RU 7, including patches of petran montane conifer forest on the higher mountains, including Burro Mountain, in the vicinity of Maverick Hill and Tillie Hall Peak near the Arizona/New Mexico border, and Maple and Mitchell peaks on the Apache-Sitgreaves National Forests in Arizona. Below those communities, particularly to the south and west, but also running up the San Francisco and Blue rivers Madrean evergreen woodland occur. Mainly to the north and east of the petran montane conifer forests, but below those formations, Great Basin conifer occurs, or pinyon-juniper woodlands. A stand of interior chaparral is found on the southwestern slopes of the Burro Mountains, and Chihuahuan Desert scrub reaches its northern extension in western New Mexico on the extreme southwestern edge of the RU (Brown and Lowe 1980).

Chiricahua Leopard Frog Populations

Chiricahua leopard frogs were historically well-distributed in at least the New Mexico portion of RU 7, including records from the Gila River, Duck Creek, Mangas Springs, Blue Creek, Lemmons Creek, Cherry Creek, Kemp Creek, among others. Few records exist for the Arizona portion of the RU, but the species is still extant on Coal Creek and two adjacent tributaries of the San Francisco River and a nearby stock tank. Chiricahua leopard frogs have declined dramatically in the New Mexico portion of the RU and are only known to be extant at a single site in lower Blue Creek. Recent genetic analysis and apparent morphological characteristics suggest that Chiricahua leopard frogs in RU 7 may be more closely related to the southern populations in RUs 1-4, than to adjacent populations in RUs 5, 6, and 8.

Current Land Uses and Management

The primary land owner/manager in RU 7 is the Forest Service. Gila National Forest manages the higher country in the Burro Mountains and west and south of Mule Creek. The Apache-Sitgreaves National Forest manages most lands in the Arizona portion of the RU. Forest lands in New Mexico are managed in accordance with the 1986 Gila National Forest Plan. Forest lands in Arizona in RU 6 are managed pursuant to the 1987 Apache-Sitgreaves National Forest Plan. These plans prescribe multiple use management for recreation, wildlife, timber production,


6
5
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Deep Creek Divide
West-Middle Fork
East Fork
Mule Creek
Lemmons Peak
Burro Mountain
Lampbright/San Vicente
Rio Mim
CLIFTON
PIMA
THATCHER
SAFFORD
VIRDEN
SILVER CITY
BAYARD
HURLEY
Figure B7. Chiricahua Leopard Frog - Recovery Unit 7
Cities and Towns
Drainages
Management Areas
Recovery Units
State Boundaries
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USFWS/AES/Ottner December 2004

livestock production, wilderness values, and a variety of other uses. See the description for RU 6 in regard to recent changes in grazing management and associated litigation.

Near Buckhorn, Cliff, and Gila, New Mexico, and southwest to the border of RU 7, are scattered, checkerboard lands, often scattered or checkerboarded, owned and managed by private individuals, the New Mexico State Land Office, and the BLM. The State Land Office is responsible for administering surface and subsurface lands for the beneficiaries of the State land trust. Each acre of land is designated to a specific beneficiary, with public schools receiving more than 90 percent of the acreage. The goals of the trust are to optimize revenues while protecting the health of the land for future generations. Livestock production is a primary use of State Trust lands in New Mexico portions of RU 7. The BLM lands are managed by the Las Cruces Field Office in accordance with their Resource Management Plan.

Threats

A History of Land Uses - Past and Current Threats
During the first few centuries AD, growing Native American populations and increased competition for resources precipitated increased development of societies and economies designed to cultivate maize and other crops, recently introduced from Mexico. By 400 AD, most of the population in western New Mexico had begun to settle into semi-permanent or permanent agrarian villages along rivers. The people who settled in the southwestern part of the state are known as Mogollon. These peoples apparently abandoned the area between 1200 and 1400, concurrent with similar abandonment by native peoples elsewhere in other RUs. Villages were probably abandoned for a variety of reasons, but it is generally believed that subtle but prolonged climatic changes (especially a severe drought in the late 1200s), increasing demographic pressures on the environment, and attacks by nomadic tribes contributed substantially to this abandonment.

The Chiricahua Apache ranged through the area after the Mogollon period. Many local ranches, towns, missions and small mining stakes suffered heavily from raids in the 18th century. The Gila Apache Indian Reservation was established in the RU by the U.S. Government in 1853, but was abolished in 1878.

After the Civil War, one of the early settlers, Joseph Hooker, and his descendants put together one of the first and largest working cattle ranches in Grant County, New Mexico, northwest of Gila and Cliff, comprised of nearly 70,000 acres. Cattle ranching began in earnest after the Apaches were subdued in the late 1880s and with the building of the railroads, which provided easy access for settlers and commerce. Cattle ranching continues to be a major economic activity in RU 7.

There is abundant evidence of mining, particularly in the mountains, but most is historical in nature. A large copper mine, established in 1872, is operated near Clifton, Arizona, to the south of the RU.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	High	High
Infectious Disease	Very High	Very High	Very High
Aquatic patch degradation	Medium	Medium	Medium
Aquatic patch loss	Low	Medium	Low
Contaminants	Low	Low	Low
Reduced connectivity	Low	Low	Low

Table B13: Viability Summary, RU 7

Threats Assessment: 2004-2014
Tables B13 and B14 display the results of the threats assessment for RU 7. Infectious disease (chytridiomycosis and perhaps iridovirus) is the most important threat to this RU. Populations and metapopulations have been lost to disease in New Mexico within the last 15 years. American bullfrogs and tiger salamanders can be carriers of the disease. Predation by non-native species is the next most important stress, with American bullfrogs, non-native fishes, and crayfish contributing equally to this stress. Aquatic habitats are relatively intact and secure compared to other RUs, thus aquatic habitat loss and degradation are relatively low stressors. For the same reasons, reduced connectivity is ranked as a low stressor. Contaminants are not an important stressor in this RU; however, cattle feces and fire retardants pose some threat.

Past or Ongoing Chiricahua Leopard Frog Conservation

The effects of livestock grazing activities and possible conservation measures in the Pleasant Valley and Hickey allotments in Apache-Sitgreaves National Forest is currently being discussed. No other conservation has taken place in this RU.

Management Areas (see Figure B7)

San Francisco River MA[1, 2] (potential for metapopulation and buffer). Includes the Mule Creek-San Francisco River, Big Pine, and Mule HUs (all).

Lemmons Peak MA (potential for metapopulation and buffer). Includes the Blue, Redrock, and Sycamore HUs.

Mule Creek MA (potential for large isolated population and buffer). Includes the Big Pine, Mule, Dry, and Pleasanton HUs.

Burro Mountain MA (potential for large isolated population and buffer). Includes Swan and Mangas HUs.

Notes:

1. Based on AZ 5th code HUs, except Upper Verde River MA and Gentry Creek MA, and MAs that contain HUs that border New Mexico. These MAs were based partially or wholly on 6th code HUs.

2. The drainages of HU(s) in this MA are in Arizona and New Mexico.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	Very High	Medium				Low	High
	Irreversibility	Very High	High				High	
	Override							
	Source	Very High	Medium				Medium	
	Combined Rank	High	High				Low	
Non-native fishes	Contribution	Very High					High	High
	Irreversibility	Very High					Very High	
	Override							
	Source	Very High					High	
	Combined Rank	High					Low	
Crayfish	Contribution	Very High		Medium			Medium	High
	Irreversibility	Very High		Very High			Very High	
	Override							
	Source	Very High		High			High	
	Combined Rank	High		Medium			Low	

Table B14: Recovery Unit 7: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Hydrologic Alteration	Contribution			Low	Low		Medium	Low
	Irreversibility			High	High		High	
	Override							
	Source			Medium	Medium		Medium	
	Combined Rank			Low	Low		Low	
Chytrid fungus	Contribution		Very High					Very High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		Very High					
Dirt stock Tank Manage-ment	Contribution	Medium		Medium	Low	Low	Medium	Low
	Irreversibility	Low		Low	Medium	Low	Low	
	Override							
	Source	Low		Low	Low	Low	Low	
	Combined Rank	Low		Low	Low	Low	Low	
Ungulate Grazing	Contribution			Medium	High	Medium	Medium	Low
	Irreversibility			High	High	High	High	
	Override							
	Source			Medium	High	Medium	Medium	
	Combined Rank			Low	Low	Low	Low	

Table B14: Recovery Unit 7: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution	Low	Low	High	Very High	Low	Low	High
	Irreversibility	Medium	High	High	Very High	Low	High	
	Override							
	Source	Low	Medium	High	Very High	Low	Medium	
	Combined Rank	Low	High	Medium	Low	Low	Low	
Non-native tiger salamanders	Contribution		Low					High
	Irreversibility		High					
	Override							
	Source		Medium					
	Combined Rank		High					
Iridovirus	Contribution		Low					High
	Irreversibility		High					
	Override							
	Source		Medium					
	Combined Rank		High					

Table B14: Recovery Unit 7: Sources of Stress

RECOVERY UNIT 8: BLACK-MIMBRES-RIO GRANDE

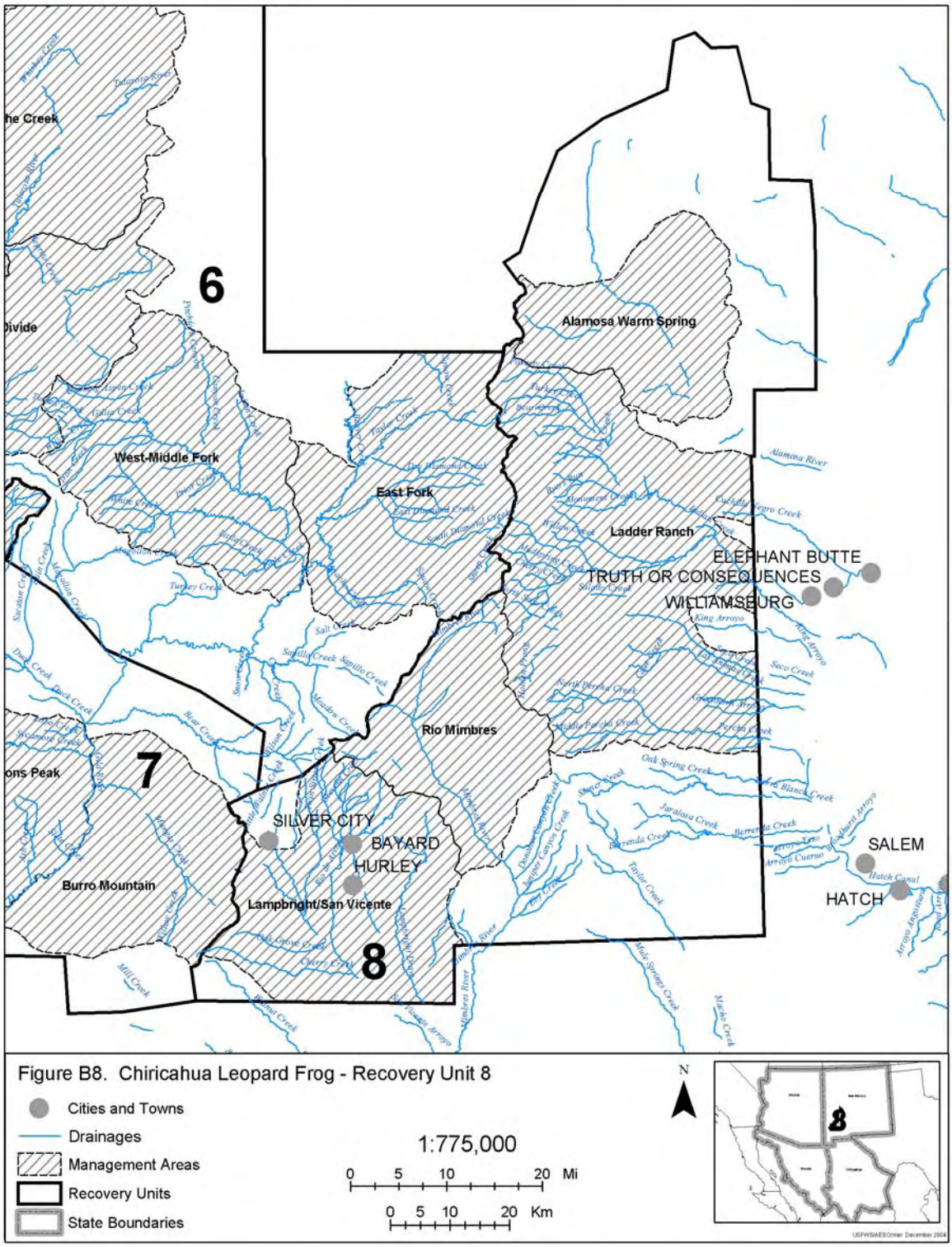
Environmental Setting

RU 8 includes lands in the Mimbres River drainage, a closed-basin drainage, and the Rio Grande drainage to the east (Figure B8). On the southwest, the RU borders RU 7 on the eastern side of the Burro Mountains, extends to the north of Silver City and east into the Black Range, then north to the Cibola National Forest and the San Mateo Mountains. From there the boundary runs south along the eastern bajada of the Black Range, including the Ladder Ranch, to about the Luna County line and then west to the Black Range. The highest elevations in RU 8 are in the Black and San Mateo mountains, with several peaks over 9,000 feet. The lowest elevations are below 5,000 feet in San Vicente Arroyo, a tributary to the Mimbres River, and on the eastern bajada of the Black Mountains. The RU includes the towns of Silver City, Ft. Bayard, Hurley, San Lorenzo, and others in the upper Mimbres drainage.

Similar to RU 6, this RU has extensive coniferous forests at the higher elevations. Above roughly 8,000 feet in the Black and San Mateo mountains are extensive stands of petran subalpine conifer forest communities, characterized by Engelmann and blue spruce, subalpine fire, corkbark fir, and other high-elevation conifers. These forests are relatively wet and cold. Below this spruce/fir forest is petran montane conifer forest, including Ponderosa pine and mixed conifer communities. Extensive stands of petran montane conifer forests occur in the San Mateo and Black mountains, and in the Pinos Altos Mountains north of Silver City. Below the petran montane conifer forest, typically at elevations of 4,900-7,500 feet, are large areas of Great Basin conifer woodland, or pinyon-juniper. At the lowest elevations, along the Mimbres River, San Vicente Arroyo, and the eastern bajada of the Black Mountains are semi-desert grasslands. A community of Madrean evergreen woodland, more typical of the southern RUs, lies northwest of Silver City at the base of the Pinos Altos Mountains, and also at lower elevations on the eastern slope of the Burro Mountains (Brown and Lowe 1980).

Chiricahua Leopard Frog Populations

Historically Chiricahua leopard frogs were well-distributed in the southern and central portions of RU 8. Many localities are known from near Silver City and White Signal, in drainages near Hurley, along the Mimbres River, in the Mimbres Mountains, and on the eastern bajada of the Black Mountains in the Rio Grande drainage, particularly on the Ladder Ranch. A currently extant population at Alamosa Warm Springs in the Monticelo drainage of southwestern Socorro County is at the northeastern edge of the known range of the species. The San Mateo Mountains on the Cibola National Forest, located farther northeast, are included in RU 8 because of their proximity to this locality and presence of suitable or potential habitat. However, surveys for frogs on the Cibola National Forest at all potential habitats within five miles of the Alamosa Warm Springs population have been negative. There is a lack of perennial water and probably little recovery potential in this area of the Cibola National Forest. Elsewhere in RU 8, extant populations occur at Cuchillo Negro Warm Springs, Palomas, Seco, and Cave creeks, Sierra County; and along the Mimbres River, tributaries of Lambright Draw and Whitewater Creek, Grant County. At one locality, Cuchillo Negro Warm Springs, Chiricahua leopard frogs co-occur with Plains leopard frogs.



Chytridiomycosis has been documented in populations of Chiricahua leopard frogs on the Ladder Ranch, Cuchillo Negro Warm Springs (Christman *et al.* 2003), lower Mimbres River,

and Alamosa Warm Springs. Near Hurley, chytridiomycosis was the likely cause of decline and perhaps extinction of populations in West Lampbright, Main Rustler, West Rustler, and Martin canyons (R. Jennings, pers. comm. 2004).

Current Land Uses and Management

Large continuous tracts of land are managed by the Gila National Forest in the Black, Pinos Altos, and Mimbres mountains, and by the Cibola National Forest in the San Mateo Mountains. From Silver City south to the RU boundary and east and just south of the Mimbres Mountains, and then along the bajada of the Black Mountains are large tracts of private lands, as well as parcels of State and BLM lands. BLM lands are primarily in minor mountains ranges, such as the Whitehorse Mountains, Town Mountain, and Lone Mountain, while the State lands are more often in flatter, lower country.

Lands on the Gila National Forest are managed in accordance with the 1986 Gila National Forest Plan, as amended. The 202,016-acre Aldo Leopold Wilderness covers much of the Black Range on the Gila National Forest. See description for RU 6 for more information about land management on the Gila National Forest. Forest lands on the Cibola National Forest are managed under the 1985 Cibola National Forest Land and Resource Management Plan, as amended. BLM lands are managed by the Las Cruces and Socorro Field Offices under their respective Resource Management Plans. Forest and BLM lands are managed for a variety of multiple uses. State lands are managed by the New Mexico Land Office. A primary use of all State, Federal, and private lands in RU 8 is livestock production.

Phelps Dodge Corporation operates the Chino Copper Mine and smelter near Hurley. Chino is a large open pit mine, once the largest in the world. In 2003, Local 890 of the steelworkers union and Albuquerque-based Southwest Research and Information Center sued Phelps Dodge for alleged heavy metals contamination from the Chino Mine.

The Ladder Ranch is a 155,550-acre property on the eastern bajada of the Black Range. It is owned by the Turner Foundation and reportedly has the greatest wildlife diversity of any Turner Enterprises properties. The property is a mix of ecosystems ranging from desert grasslands to pine forests in the foothills of the Black Range. The ranch is managed for conservation purposes and supports a productive herd of bison. No cattle are grazed on the Ladder Ranch. The ranch has several extant populations of Chiricahua leopard frogs, and active management and research on Chiricahua leopard frogs is ongoing. A nearby copper mine reportedly could potentially lower groundwater elevations to meet mining demands. This in turn could affect stream flows.

The Nature Conservancy manages the Mimbres River Preserve, which is managed for biodiversity. TNC owns properties along the Mimbres and also works with other landowners in the area on cooperative conservation projects.

The Upper Gila Watershed Alliance (UGWA) is a grassroots and community-based conservation organization that operates from the rural communities of Gila and Cliff. The members of UGWA recognize a vital and necessary connection between their individual and collective rights and responsibilities as landowners and community members, and the long-term stewardship of

the upper Gila River and watershed. To realize their vision for the common benefit of the entire community served by the upper Gila watershed, and for the sake of future generations, UGWA seeks ways and means to bring people and organizations together in constructive dialogue and activities aimed at clear communication, education, land restoration, research, and local economic health.

Threats

A History of Land Uses - Past and Current Threats
The early human history of RU 8 is similar to that of RU 7. The Mogollon people and then the Mimbres culture lived in the area until about 1200-1400, when the area was abandoned. Archeologists believe the Mimbres culture evolved from the Mogollon culture, which itself possibly evolved from the Anasazi and/or the Hohokam cultures. It is speculated that the original Mimbrenos moved away, and were integrated into other cultures, possibly to the south. It is not likely that they were driven from the area by warfare, as evidence points to an exodus extending over a period of years. It is possible that the Mimbrenos exhausted the natural resources of the area, and were forced to relocate, or were forced to move due to drought. Apaches tribes later replaced the Mimbres culture.

RU 8 has a rich history of mining for copper, silver, gold, turquoise and other minerals. In 1801 or 1802, an Apache chief reportedly disclosed a copper location to Colonel Carrasco, an officer in the Spanish militia. A copper mine was established there, and in 1804 the Santa Rita Del Cobre Fort was built near the mine. This site eventually became the location of Santa Rita and the Chino Copper Mine, which has been mined continually for almost two centuries. A replica of the fort now stands at Pinos Altos, northeast of Silver City. Additional mining occurred in the 1800s at Pinos Altos near Bear Creek, Chloride Flat (west of Silver City), and at Chloride on the east slope of the Black Range. There is no information to evaluate how Chiricahua leopard frogs may have been affected; however, early mining and associated water diversions, timber and fuel wood harvest, contaminants, and development probably caused localized adverse affects to the frogs and their habitats. Evidence of mining activities from the 1800s and early 1900s is still apparent throughout much of RU 8.

In the past, overgrazing by livestock damaged watersheds and grasslands, promoted conversion of grasslands to shrublands and juniper woodlands, and degraded riparian areas. Increasing efforts since the 1970s have been made by the National Forests to control effects of livestock. See discussion for RU 6 for a further history of livestock grazing and recent litigation and court settlements.

Threats Assessment: 2004-2014
Tables B15 and B16 display the results of the threats assessment for RU 8. Infectious disease (chytridiomycosis and potentially iridovirus) is considered the most important stress in RU 8. Chytridiomycosis has been documented on the Ladder Ranch and has been associated with numerous declines and extirpations in New Mexico. American bullfrogs and tiger salamanders are carriers of the disease. Extraordinary predation is the next most important stress. Crayfish are the most important contributor to that predation, but American bullfrogs and non-native fishes, and to a much lesser degree, non-native tiger salamanders, also account for extraordinary

predation. Aquatic habitat degradation is considered a medium stressor. Poor grazing practices and catastrophic fire, and to a lesser degree, hydrologic alteration, are the important contributing factors to habitat degradation. Catastrophic fire is the primary contributor to habitat loss, but overall, habitat loss was ranked a low stressor in RU 8. Contaminants and reduced connectivity are considered low stressors, as well. Ash flow and fire retardants associated with catastrophic fire and fire suppression are the sources of contamination. Reduced connectivity results from habitat loss or degradation from non-native species, stock tank management (or mismanagement), hydrologic alterations, poor grazing practices, and catastrophic fire.

Stresses – Altered Key Ecological Attributes	**Severity**	**Scope**	**Stress**
Extraordinary Predation	Very High	High	High
Infectious Disease	Very High	Very High	Very High
Aquatic patch degradation	Medium	Medium	Medium
Aquatic patch loss	High	Low	Low
Contaminants	Low	Low	Low
Reduced connectivity	Low	Low	Low

Table B15: Recovery Unit 8, Viability Summary

Past and Ongoing Conservation

On the Mimbres River, Randy Jennings transplanted eggs and different developmental stage tadpoles in field enclosures to determine which life stages made the best propagule for translocations. Late developmental stage tadpoles exhibited higher survivorship rates than earlier ones or eggs. The second main result of that project was that Chiricahua leopard frogs were successfully translocation onto the Nature Conservancy's property on the lower Mimbres (Dissert Property) from their property adjacent to Moreno Spring.

Chiricahua leopard frogs were first found on the Ladder Ranch in 1995. They are currently known from five drainages on the ranch. Efforts are underway to monitor populations, test for diseases, conduct radio telemetry studies, fence livestock tanks to encourage riparian plant growth, control American bullfrogs, investigate parasites of Chiricahua leopard frogs, and translocate frogs for the purpose of establishing new populations. Work is supported by the Turner Endangered Species Fund and State Wildlife Grants Program through NMDGF. Christman *et al.* (2003) summarize recent work on the Ladder Ranch.

Management Areas

Four MAs are designated in RU 8 (Figure B8):

Rio Mimbres MA (potential for metapopulation and buffer). Includes the Upper Mimbres HU.

Lambright/San Vicente MA (potential for metapopulation and buffer). Includes the San Vicente and Lampbright HUs.

Ladder Ranch MA (potential for metapopulation and buffer). Includes the Cuchillo Negro, Palomas, Seco, Las Animas, and Percha HUs.

Alamosa Warm Spring MA (potential for large isolated population and buffer). Includes the Kinsley HU.

Sources of Stress		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Bullfrogs	Contribution	High	Medium				Low	High
	Irreversibility	Very High	High				High	
	Override							
	Source	High	Medium				Medium	
	Combined Rank	High	High				Low	
Non-native fishes	Contribution	High					High	High
	Irreversibility	Very High					Very High	
	Override							
	Source	High					High	
	Combined Rank	High					Low	
Crayfish	Contribution	Very High		Medium			Medium	High
	Irreversibility	Very High		Very High			Very High	
	Override							
	Source	Very High		High			High	
	Combined Rank	High		Medium			Medium	

Table B16: Recovery Unit 8: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Hydrologic Alteration	Contribution	Medium		High			Medium	High
	Irreversibility	Very High		High			Very High	
	Override							
	Source	High		High			High	
	Combined Rank	Very High		High			Medium	
Chytrid fungus	Contribution		Very High					Very High
	Irreversibility		Very High					
	Override							
	Source		Very High					
	Combined Rank		Very					
Dirt stock Tank Manage-ment	Contribution	Medium					Medium	Low
	Irreversibility	Low					Low	
	Override							
	Source	Low					Medium	
	Combined Rank	Low					Low	
Ungulate Grazing	Contribution			High			Medium	Low
	Irreversibility			Medium			High	
	Override							
	Source			Medium			Medium	
	Combined Rank			Low			Low	

Table B16: Recovery Unit 8: Sources of Stress

Sources of Stress (continued)		Extraordinary Predation	Infectious Disease	Aquatic patch degradation	Aquatic habitat loss	Contaminants	Reduced Connectivity	Threat to System Rank
Catastrophic Fire	Contribution	Low	Low	High	Very High	High	Low	High
	Irreversibility	High	High	High	Very High	High	High	
	Override							
	Source	Medium	Medium	High	Very High	High	Medium	
	Combined Rank	Medium	High	Medium	Low	Low	Low	
Non-native tiger salamanders	Contribution	Low	Low					High
	Irreversibility	High	High					
	Override							
	Source	Medium	Medium					
	Combined Rank	Medium	High					
Iridovirus	Contribution		Low					Medium
	Irreversibility		High					
	Override							
	Source		Low					
	Combined Rank		Medium					

Table B16: Recovery Unit 8: Sources of Stress

APPENDIX C

Population and Habitat Viability Analysis

The PHVA Workshop was held 6-9 December 2004 at the Beatty's Guest Ranch in Miller Canyon near Sierra Vista, Arizona (Figures C1 and 2). The Workshop was led by Phil Miller and Juan Cornejo of the Conservation and Breeding Specialist Group (CBSG) and attended by 22 members of the Technical and Stakeholders Subgroups of the Recovery Team. Funding for CBSG was provided by the BLM – Arizona State Office and the Turner Endangered Species Fund. The Beatty's provided lodging and a venue for the workshop. After an introductory plenary session, the recovery team members were divided into three workings groups: Population, Habitat, and Modeling. The Modeling group developed a population viability model that mathematically allowed testing of various management scenarios and identification of population parameters most important in determining population viability. Over the course of the four-day workshop, the working groups periodically reconvened into plenary sessions to assess progress and exchange ideas.

The Population and Habitat groups identified issues surrounding recovery relevant to populations or habitats of the Chiricahua leopard frog, then prioritized those issues, listed all information about the issues, and prioritized the uncertainty of that information. The two groups then developed goals for resolving high priority issues. Issues corresponded to threats and goals were equivalent to recovery strategy elements in part 1 of this recovery plan. The groups then cross-checked threats and strategy elements, as well as recovery actions in the draft plan to make sure it contained all necessary background and actions needed to address the issues. If deficiencies were found, the groups recommended changes to the plan. The PHVA provided a forum for recovery team members to work together in small groups over four days and discuss and explore issues and solutions to a degree that had not been possible in previous meetings lasting only five or six hours. The Beatty's Guest Ranch, where most team members stayed, also provided a casual venue for after-hours discussions and reflection on the day's proceedings.

The Population and Habitat groups produced a report by the end of the meeting with their findings and recommendations. The Modeling group finished with recommendations for Dr. Phil Miller to run additional scenarios. Dr. Miller completed the modeling and the group's report, a summary of which is included below with summaries of the Population and Habitat group's report. A key finding from the latter two groups was that administrative and political barriers and a lack of cultural value ascribed to the Chiricahua leopard frog were threats or barriers to recovery that needed to be described in the "Reasons for Listing/Threats" section in part 1 of the plan. To address these challenges, the groups recommended expansion of recovery action 7 "Develop and implement public outreach and conduct broad-based community planning to promote public support and understanding of recovery actions" and added detail below on how to implement that action. Additional recommendations were made regarding funding and priority levels for recovery actions, emphasizing the need for agency cooperation, and the need to enhance bankline and streamside vegetation at habitat sites. The Modeling group's key findings were that population viability is particularly sensitive to juvenile survivorship, the extent of female reproductive success (defined as the proportion of adult females that were

able to produce metamorphs) and the average number of metamorphs per successful female.

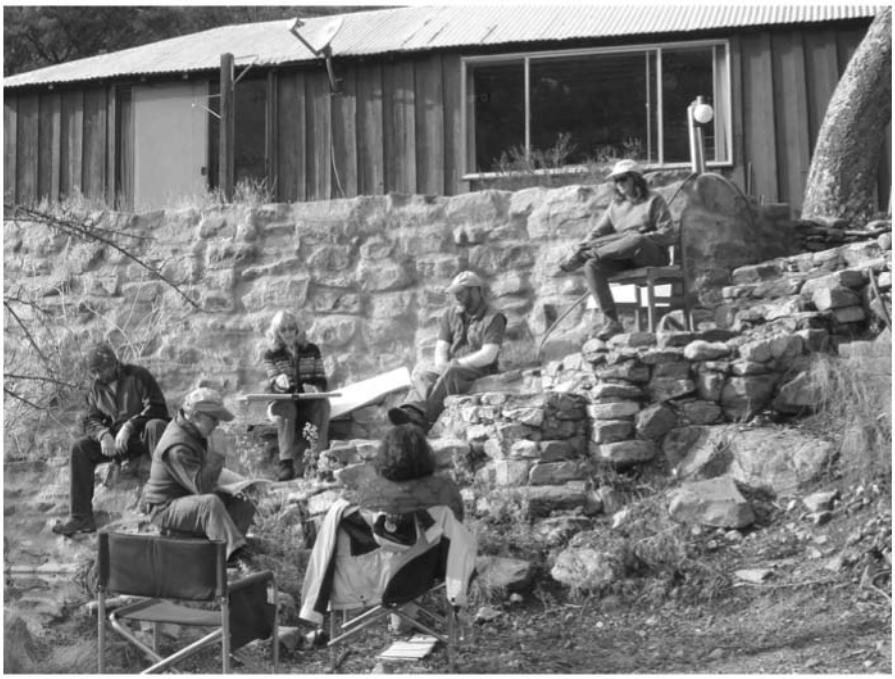


Figure C1: Habitat group at Beatty's Guest Ranch. From right to left: Doug Powers (BLM), Sheridan Stone (Fort Huachuca), Anna Magoffin (Magoffin Ranch, Malpai Borderlands Group), Stefanie White (San Carlos Apache Tribe), Trevor Hare (Sky Island Alliance), and Jeanmarie Haney (The Nature Conservancy).

Figure C2: Deliberations on the population viability modeling, Beatty's Guest Ranch.

Population viability declines rapidly in populations of less than 60 adults, or less than 40-50 adults in habitats resistant to drought; moreover, small populations (~10 adults) do not contribute much to viability of metapopulations and may serve as population sinks. Also, to properly assess the likelihood of population persistence, monitoring should occur over a period of more than 15 years. The complete findings and recommendations of the three groups are summarized here. The full text of the Population and Habitat groups' reports are included in the administrative record for this recovery plan. Note that their findings were based on internal drafts available in December 2004. The current version has been revised in accordance with these findings and recommendations.

POPULATION GROUP'S SUMMARY FINDINGS AND RECOMMENDATIONS FOR THE RECOVERY PLAN

Issue Statement

The following primary issues were identified and ranked as to their importance:

1) Administrative and political barriers to recovery (High)
2) Metapopulation dynamics (extent, distribution, and suitability of habitat) (Medium)
3) Disease (Very High)
4) Predators and competition (Very High)
5) Lack of resources for artificial enhancement of populations (Low)
6) Maintenance of regional genetic diversity (Medium)
7) The frog lacks cultural value in our society (High)
8) Direct anthropogenic effects (Low)

Threats to the frog and its habitat include direct anthropogenic activities, such as human population increases, demands for food, land conversion, road construction, pollution, and increased wildland interface and recreation. This results in fragmentation and conversion of additional habitat. It converts land uses near urban population centers from rural ranch lands that contain frogs. Use of frogs for food items in parts of the range (Mexico) may be locally significant. In addition, some collection for backyard pond and pet trade may occur. Management of non-native species, policies that create barriers to reestablishment of native species, air-borne and water-borne contaminants, and habitat fragmentation due to roads, subdivisions, and mining are additional challenges.

The frog lacks social or cultural value. In general the value of this organism to society is unknown. Why would society in general decide to conserve a species for which it does not understand the significance? Finally, we are lacking knowledge in many aspects of frog biology that will make recovery even more challenging.

The Populations Group examined the recovery plan to see if it adequately addressed the issues identified above. The group found that the plan needed to be strengthened in regard to identifying administrative and political barriers, and a lack of cultural value, as threats to recovery. Once identified in Part 1 of the plan, these issues then needed to be reflected in the

recovery strategy and recovery actions in Part II. The following concepts were outlined for building broad-based community support for recovery. It was thought that if communities and individuals on a local level support recovery, administrative and political factors are less likely to be significant barriers to progress. The group also endorsed the Habitat Group's recommendations for comprehensive education and outreach to address the cultural value issue (see below).

- Keep working groups on a scale that is manageable, but with communication and coordination among groups
    - Regional (perhaps at the level of an RU)
    - Statewide-coordinate regional groups
    - Public outreach- keep process transparent to avoid an 11th hour catastrophe
        - Use phone, email, and websites so all can be involved
    - Look for incentives to conduct recovery (i.e. Beatty's Guest Ranch and ecotourism)
        - Selling/marketing the project to the cooperators
- Build coalitions
    - Needs to be broad group that includes stakeholders and scientists, community-based planning
    - Should include opposing viewpoints
    - Persistence
    - Bring meetings to the community, insist on participation by all at meetings
    - Design early win-win situation to create bonding among members - people see they can work together - and then build momentum to address more difficult issues
    - Define roles and methods of resolving conflicts, and employ a good facilitator to identify problems and move to solutions
    - Keep decision-makers aware of progress of coalition and give feedback so group performs to their expectations
- Identify sources of funding and capture funding
    - All cooperators need to make effort to secure funding from sources of which they are aware, but are not necessarily known to the group as a whole
    - Commitment from all participants to seek funding
    - Coordinator to oversee process and ensure that recovery is moving forward and funds are being secured
    - Decision-makers are aware of available funding
- Amplify efforts by expanding coalitions to include other species, ecosystems, and issue resolution
    - Restoration of a natural assemblage approach

Based on these concepts, the Population Group then wrote text for the recovery plan to be inserted at specified locations that addressed the issues not covered adequately, and that further developed recovery strategies and actions relevant to these issues.

HABITAT GROUP'S SUMMARY FINDINGS AND RECOMMENDATIONS FOR THE DRAFT RECOVERY PLAN

Education/Outreach (1st priority)

Issue Statement

- Target specific user groups - ranchers, sportsmen, off-highway vehicle users, K-12
- Target specific geographic areas near extant populations of Chiricahua leopard frogs
- Use professionals to develop education and outreach materials and messages
- Need a more basic level of education, and more law enforcement, signing, deterrents

Need more funding for the following three recovery actions dealing with public outreach in the Recovery Plan step-down narrative:

- 7.2 Post and maintain signs to inform the public of land-use restrictions
- 7.3 Develop outreach materials to inform the public and build support for frog recovery
- 7.4 Continue momentum through Stakeholder and Recovery Groups

Need additional education/outreach activities. General sense is that past education-outreach efforts have not been enough to adequately gain public and user group support for frog recovery.

Recommendations

Specific suggestions for additional education/outreach activities and information resources:

- Sub-contract with Environmental Education Exchange or other contractor TREE, Project WILD, Project WET
- Develop curricula for Douglas school system and other targeted areas
- Hopkins/NRCD resource center – working with specific sites with extant leopard frogs
- Arizona Partners in Amphibian and Reptile Conservation (PARC) – are developing curriculum for 4th graders on reptile and amphibian conservation. Dovetail with frog conservation.
- Based on environmental education research, target 4th graders
- K-12 teachers often eager to have visitor presentations in class. Develop a speakers' bureau to give presentations to classrooms.
- Hire a public relations firm to develop a message about endangered species/Chiricahua leopard frogs, which may include logos, phrases, mottos, branding – public relations professionals have skills that scientists do not.
- Conduct coordination meetings with targeted land user groups, including:
    - Grazing permittees – USFS, BLM – including developing habitat and population protection specifications for inclusion into grazing permits
    - Special use permits – horseback riders, etc – develop information that would accompany their permit
    - Range conservationists and maintenance workers – train/educate them to collect information on frogs in the course of their work
    - Targeted geographic areas and user groups plus opportunistic education
    - Use volunteers from non-profit conservation organizations to accomplish recovery work (e.g. Sky Island Alliance, Audubon, Arizona Riparian Council, Native Plant Society)

- Develop educational materials to target off-highway vehicle dealerships and user groups
- Develop materials and presentations for BLM and USFS Resource Advisory Councils and other public agency advisory groups
- Inject need for frog recovery into Forest Plan Revisions, for which public meetings are beginning

Bald Eagle outreach has successfully used pamphlets and the Bald Eagle Nest Watch Program as educational outreach. Investigate using this as a model for Chiricahua leopard frog recovery, e.g. "Pond Watchers" could be used to collect frog data.

Agency Cooperation/Coordination (2nd priority)

Findings and Recommendations

- Continuing education and professional development as needed for agency staff in regard to techniques for riparian restoration and frog management.
- Need additional accountability of agency managers to implement recovery plan actions - there is a statutory responsibility within section 7(a)(1) and elsewhere in the ESA regarding this.
- Within the plan, clear identification is needed as to which agency is responsible for which actions (need clear statement in the Implementation Schedule). Each agency should designate an individual representative responsible for overseeing frog recovery. Agencies should report in a written document what has been accomplished on an annual basis (see recovery action 7.4.
- Small projects with a low risk and costs will be easier to gain cooperation from user groups and build trust for future actions.
- Coordination in New Mexico is easier than in Arizona due to more people / agencies / organizations with which one needs to coordinate. As a result, agency coordination is a larger issue in Arizona.

Habitat Restoration (3rd priority) and Habitat Protection (4th priority)

Findings and Recommendations

Vegetation cover at pond and stream sites provides protection for juveniles from predation; populations are very sensitive to juvenile mortality (from the Modeling group). Therefore, a primary focus of habitat management actions should be recovery of bankline and streamside vegetation. In addition, habitat heterogeneity should allow for greater reproduction, recruitment, and juvenile survival. A major impediment to management for bankline and streamside vegetation is the multiple use mandate on most BLM and USFS public lands. Willing private landowners may provide good opportunities for recovery actions.

Solutions:

- Safe Harbor Agreements (private lands)
- Application of the 4d rule (non-Federal lands)
- Outreach to alleviate land owner uncertainty

- Messaging – obtain assistance from professionals (see Education/Outreach recommendations above)

Add an additional Appendix to Recovery Plan:

Non-native aquatic species removal/control

Include stakeholder involvement in identification of potential re-establishment sites

Need Data Roll-up:

Need data synthesis, analysis, and presentation and information in a manner to document/justify/prioritize land protection (including land acquisition)

The solutions are political and educational:

Insufficient funding for appropriate management of public lands
Insufficient funding for conservation easements/acquisitions of private lands
(For the above two items, the Population Management group has good thoughts in their notes on Administration/Institutional Barriers)

Additional Recommendations for the Recovery Plan:

Semlitsch (2003) has relevant references on protection of watershed and riparian biodiversity. In the Implementation Schedule add funding for education/outreach
In this Participation Plan, address specifically "who to call" for instance, when a pond with frogs is drying

MODELING GROUP'S REPORT

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Introduction

The Chiricahua leopard frog occurs at elevations of 3,281 to 8,890 feet in central and southeastern Arizona; west-central and southwestern New Mexico; and northern Sonora and the Sierra Madre Occidental of Chihuahua, Mexico. The range of the species is split into two disjunct parts - the northern populations along the Mogollon Rim in Arizona east into the mountains of the west-central New Mexico, and the southern populations in southeastern Arizona, southwestern New Mexico, and Mexico. Threats to this species include predation by non-native organisms, especially American bullfrogs, fish, and crayfish; a fungal disease - chytridiomycosis; drought; floods; degradation and loss of habitat as a result of water diversions and groundwater pumping, poor livestock management, a long history of fire suppression that has resulted in scouring of montane creek bottoms and cienegas, mining, development, and other human activities; disruption of metapopulation dynamics; increased chance of extirpation or extinction resulting from small numbers of populations and individuals existing in dynamic environments; and probably environmental contamination (such as runoff from mining operations and airborne contaminants from copper smelters). Loss of Chiricahua leopard frog populations fits a pattern of global amphibian decline, suggesting other regional or global causes of decline may be important as well, such as elevated ultra-violet radiation, pesticides or other contaminants, and climate change.

To date (December 2004), the internal draft Recovery Plan has not included an intensive and detailed quantitative risk assessment, based on the concepts of population viability analysis (PVA). An analysis of this type, particularly when combined with public involvement in the interpretation of PVA results and their use in the construction of integrated and achievable species and habitat management alternatives, can be an extremely useful tool for investigating current and future risk of wildlife population decline or extinction. In addition, the need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in managing populations of the Chiricahua leopard frog in its wild habitat in the southwestern United States. *VORTEX*, a simulation software package written for population viability analysis, was used here as a tool to study the interaction of a number of leopard frog life history and population parameters treated stochastically, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected management scenarios.

Specifically, we were interested in using this preliminary analysis to address the following questions:

- What is our depth of understanding of the population biology of the Chiricahua leopard frog?
- Based on this understanding, what do we see as the primary drivers of leopard frog population growth? To which parameters is our demographic model most sensitive?
- How vulnerable are small, fragmented Chiricahua leopard frog populations to local extinction in the absence of demographic interaction with other populations?
- Is the current Recovery Plan definition of a "robust population" adequate in terms of relative risk of population extinction?
- What is the relative risk to leopard frog population viability posed by drought in lentic vs. lotic habitats?
- What are the relative levels of importance of subpopulation size and dispersal rate within a given metapopulation in terms of metapopulation viability?
- Under what set of subpopulation characteristics (e.g., population size, dispersal rates, and management intensity) can we observe a functioning metapopulation?

The *VORTEX* package is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by stepping through the series of events that describe the typical life cycles of sexually reproducing, diploid organisms.

PVA methodologies such as the *VORTEX* system are not intended to give absolute and precise "answers", since they are projecting the interactions of many randomly-fluctuating parameters used as model inputs and because of considerable measurement uncertainty we observe in typical wildlife population demography datasets. Because of these limitations, many researchers have cautioned against the sole use of PVA results to promote specific management actions for threatened populations (e.g., Ludwig 1999; Beissinger and McCullough 2002; Reed *et al.* 2002; Ellner *et al*. 2002; Lotts *et al*. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of the output depends upon our knowledge of the biology of the Chiricahua leopard frog in its habitat, the environmental conditions affecting the species, and possible future changes in these conditions. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Appendix I, Lacy (2000) and Miller and Lacy (2003).

The *VORTEX* system for conducting population viability analysis is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. The program has been used around the world in both teaching and research applications and is a trusted method for assisting in the definition of practical wildlife management methodologies.

Baseline Input Parameters for Stochastic Population Viability Simulations

Throughout the discussion of our demographic model, it is important to recognize that we have slightly modified our definition of "reproduction" in order to account for the reproduction biology of Chiricahua leopard frogs within the constraints of the *VORTEX* modeling environment. In order to more effectively deal with the breeding biology of this amphibian, we are defining "reproduction" as the production of metamorphs, age approximately six months, that have then survived an additional six weeks or so to reach the full juvenile stage.

Baseline population model

Breeding System: We assume that Chiricahua leopard frogs demonstrate a polygynous mating system. Frogs can breed year-round, but do so only in hot springs. For this model, we are assuming that adult females breed once per annual cycle, although it may be possible for them to occasionally breed more frequently. Since we might expect springs to have more similar birth and death patterns than they do with the fall of the same year, then maybe it is better to model on an annual cycle. We are therefore setting our *VORTEX* time-step as equal to one year.

Age of First Reproduction: *VORTEX* considers the age of first reproduction as the age at which metamorphs are produced, not simply the onset of sexual maturity. Observational data indicate that Chiricahua leopard frogs will be a little more than one year old at the time of offspring metamorphosis, so we set the age of first reproduction at one year for both males and females.

Age of Reproductive Senescence: In its simplest form, *VORTEX* assumes that animals can reproduce (at the normal rate) throughout their adult life. Maximum known age for Chiricahua leopard frogs is 10 years based on skeletochronology at Ramsey Canyon (Platz *et al.* 1997). Phil Fernandez maintained a population of this species in a greenhouse at Grand Canyon University. Those frogs, although we assume they are unnaturally old, continued breeding. Although the age reported by Platz seems unrealistic, this is only being used to set ages at which a female can reproduce, if she lives that long. Discussion of this parameter led to an agreed maximum reproductive age equal to nine years.

Offspring Production: Data from Platz suggest that all adult females reproduce in a given year, with some perhaps double-clutching in both the spring and fall, while other habitats may experience substantially fewer females breeding. Initial discussion of this parameter led to an early estimate of no more than about 50 percent of females successfully producing metamorphs in a given year. Some group members saw this estimate as highly pessimistic, perhaps more reflective of breeding propensities in high-density situations. After lengthy discussion, the group concluded that metamorph production would be density-dependent, with as few as 50 percent of the adult females successfully producing metamorphs at high population density and as many as 100 percent reproducing successfully at low density. We assumed that the relationship between reproductive rate and population density would be linear; in other words, 100 percent of adult females would breed at low (optimal) density, about 75 percent of adult females would produce metamorphs at intermediate density, and only 50 percent would produce metamorphs at high density (near carrying capacity, K).

Annual environmental variation in female reproductive success is modeled in *VORTEX* by specifying a standard deviation (SD) for the proportion of adult females that successfully produce metamorphs within a given year. While no data are available for this parameter, we propose that annual variance would be relatively high. We therefore set the standard deviation in the percentage of adult females breeding at 13 percent.

Based on the number of juveniles in April (or August) at Big Springs, Arizona (the species was *Rana yavapaiensis*, which was used as a surrogate species) in a ratio with the number of adults in the previous interval, we estimated there were 3.2 metamorphs per adult female. However, some group members have seen as many as 20 times more juveniles in the fall than the number of adults, or 40 times the number of adult females. Moreover, in any given year some proportion of the total pool of adult females will fail to produce metamorphs (although many may actually lay eggs). Non-reproducing females will include those that fail to lay eggs or those that do lay eggs but experience total clutch failure. Taking all of this information into account, we assumed for our model that, on average, approximately 10 eggs laid by a given breeding female would survive to the metamorph – early juvenile stage.

The full distribution of metamorph production per successful female is given below.

Number of metamorphs	percent
1	0.05
2	0.23
3	0.76
4	1.89
5	3.78
6	6.31
7	9.01
8	11.26
9	12.51
10	12.51
11	11.37
12	9.48
13	7.29
14	5.21
15	3.47
16	2.17
17	1.28
18	1.42

This distribution yields an average of 9.99 metamorphs per successfully breeding female. The overall population-level sex ratio among metamorphs is assumed to be 50 percent.

Male Breeding Pool: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered “available” for breeding each year. Within any given year, we assume that about 30 percent of adult males are successful in

siring offspring (metamorphs). Based on a Poisson distribution of breeding success among males, we therefore assume that about 44 percent of adult male Chiricahua leopard frogs are available for breeding each year.

Mortality: The only data source for estimating mortality for adults and juveniles is the Big Springs population from 1991 through 1996. Mortality was available from one within-year interval to the next, so the annual survivorship was generated by multiplying the seasonal interval survivorship estimates. Survivorship was assumed to follow a binomial distribution, so the demographic, within-year variability estimated using the binomial distribution was added to the between-year, environmental variability in survivorship. We then estimated the proportion of total variability due to environmental (between-year) effects.

Using this technique, our initial estimate of adult mortality was 66.5 percent per year, with 29.1 percent of the total variability in this parameter due to environmental effects (EV). These data also indicated that the entire cohort of juveniles died between one year and the next in four of the six years considered: annual mortality was therefore estimated to be 97.6 percent with 5.5 percent due to EV. Using these data directly resulted in an extremely rapid rate of population decline and extinction within about a decade. In order to better understand our data and the biology of the leopard frog, we revisited these mortality estimates with the assumption that baseline population mortality should, at least initially, exclude natural or anthropogenic impacts that should be added later as, perhaps, catastrophic effects of incremental additions to more "natural" mortality. Coupled with the direct historical observation of persistence of leopard frog populations for extended periods of time, we refined our mortality estimates to 80 percent mortality for juveniles (EV = 5.5 percent) and 50 percent for adults (EV = 14.5 percent). Moreover, we ultimately assumed that juvenile mortality was density-dependent around a mid-point value of 80 percent at intermediate densities. At low population density, juvenile mortality was assumed to be 75 percent, with an increase to 85 percent mortality at high density. As in the case of density-dependent reproductive success, we assumed that mortality showed a linear relationship with density.

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be floods, droughts, disease, or similar events. These events are modeled in *VORTEX* by assigning an annual probability of occurrence and a pair of severity factors describing their impact on mortality (across all age-sex classes) and the proportion of females successfully breeding in a given year. These factors range from 0.0 (maximum or absolute effect) to 1.0 (no effect), and are imposed during the single year of the catastrophe, after which time the demographic rates rebound to their baseline values.
While drought may well be considered an extreme of normal climate in the Southwest, we wanted to investigate the impact of severe rainfall deficit on the persistence of threatened Chiricahua leopard frog populations. We would like to highlight the negative impacts of drought, so maybe we stay with a narrow range of precipitation, with droughts as exceptions to the pattern.

For those models in which drought was included, we assumed that such an extreme event occurs, on average, every 20 years. It is important to note, however, that these events are essentially

independent over time so that multiple events could occur within a much shorter time interval. It is also important to consider the relative impacts of drought on lentic and lotic systems. For example, springs do not generally experience a drought-based catastrophe like more isolated lentic systems (e.g., cattle tanks), since they do not dry completely. In general, lotic systems are likely to be impacted to a lesser degree than their lentic counterparts. Therefore, we set the following severity parameters for drought in each of these habitats:

		Severity	
Habitat	Frequency	Reproduction	Survival
Lentic	5 percent	0.33	0.2
Lotic	5 percent	0.66	0.4

Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding, most directly through reduced survival of offspring through their first year. While specific data on inbreeding depression in Chiricahua leopard frog populations were not available for this analysis, the strong evidence for the deleterious impacts of inbreeding in many different types of species suggests that it can be a real factor in the persistence of small populations of vertebrates. We therefore elected to include this process in some of our models, with a genetic load of 1.0 or 3.0 lethal equivalents and approximately 50 percent of this load expressed as lethal genes.

Initial Population Size: We chose to initialize our baseline model with 100 individuals, age one year and older. Subsequent sensitivity and risk assessment models were initialized with different numbers of individuals in order to address specific questions related to management of frog populations (see below).

Carrying Capacity: The carrying capacity, K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed randomly across all age classes in order to return the population to the value set for K.

Carrying capacity is typically extremely difficult to estimate in the field for any species. For the purposes of our modeling effort here, we will assume that the vast majority of Chiricahua leopard frog populations across their range are close to their ecologically sustainable maximum as they occupy increasingly smaller and more fragile habitats. Therefore, we set all values of carrying capacity equal to 1.6 times the initial population size. This “artificial” inflation of K will allow the population, through the action of density dependence for both reproductive success (metamorph production) and juvenile mortality, to maintain a long-term population size average that is close to the initial size entered into the model. For example, an initial population size of 100 individuals would include an estimated carrying capacity equal to 160 individuals.

Iterations and Years of Projection: All population projections (scenarios) were simulated 500 times. Each projection extends to 100 years, with demographic information obtained at annual intervals. All simulations were conducted using *VORTEX* version 9.45 (June 2004). Table 1 below summarizes the baseline input dataset upon which all subsequent *VORTEX* models are based.

Demographic sensitivity analysis

During the development of the baseline input dataset, it quickly became apparent that a number of demographic characteristics of Chiricahua leopard frog populations were being estimated with varying levels of uncertainty. This type of measurement uncertainty, which is distinctly different from the annual variability in demographic rates due to extrinsic environmental stochasticity and other factors, impairs our ability to generate precise predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of our models to this measurement uncertainty can be an invaluable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology. To conduct this demographic sensitivity analysis, we identified a selected set of parameters from Table 1 whose estimates we saw as considerably uncertain. We then developed biologically plausible minimum and maximum values for these parameters (see Table 2).

For each of the parameters listed we construct multiple simulations, with a given parameter set at its prescribed minimum and/or maximum value, and with all other parameters remaining at their baseline value. With the nine parameters identified above, and recognizing that the aggregate set of baseline values constitute our single baseline model, the table above allows us to construct a total of 17 alternative models whose performance (defined, for example, in terms of average population growth rate) can be compared to that of our starting baseline model. For the entire suite of sensitivity analysis models, we will consider a population whose initial size and carrying capacity is equal to that of the original baseline model, i.e., 100 and 250 individuals, respectively.

Table 1. Demographic input parameters for the baseline *VORTEX* model for the Chiricahua leopard frog in the southwest US. See accompanying text for more information.

Model Input Parameter	Baseline value
Breeding System	Polygynous
Age of first reproduction (♀ / ♂)	1 / 1
Maximum age of reproduction	9
Inbreeding depression?	No
Annual percent adult females reproducing (SD)	100.0 – [50.0*(N/K)] (13)
Maximum metamorph clutch size	18
Mean clutch size†	10.0
Overall offspring sex ratio	0.5
Adult males in breeding pool	44 percent
percent annual mortality (SD)‡	
0 – 1	75.0 + [10.0*(N/K)] (5.5)
1 +	50.0 (14.5)
Catastrophe?	Drought
Annual frequency of occurrence	5 percent
Severity: Reproduction [Lentic/Lotic]	0.33 / 0.66
Severity: Survival [Lentic/Lotic]	0.2 / 0.4
Initial population size	100
Carrying Capacity (K)	250

† Exact probability distribution of individual clutch size specified in input file.
‡ No sex-based differences in annual mortality rates.

Table 2. Uncertain input parameters and their stated ranges for use in demographic sensitivity analysis of simulated Chiricahua leopard frog populations in the southwestern United States. Values in bold are those used in the baseline model. See accompanying text for more information.

		Estimate	
Model Parameter	Minimum	Midpoint	Maximum
Age of First Reproduction (AFR)		**1**	2
Inbreeding Depression (#Leth Equiv)	**0.0**	1.0	3.0
percent Adult Females Reproducing	**50**	75	100
Average Brood Size	6	**10**	15
percent Juvenile Mortality	56	**80**	88
EV (Juvenile Mortality)	3.85	**5.5**	8.25
percent Adult Mortality	35	**50**	55
EV (Adult Mortality)	10.15	**14.5**	21.75
Drought Severity	**None**	Lotic	Lentic

Metapopulation input parameters

A major component of our risk assessment effort centered around the development of metapopulation models. In these models, we constructed four separate subpopulations with different size categories, drought regimes, and dispersal rates. Specifically, our metapopulation models were parameterized as follows:

- General dispersal characteristics: Both sexes disperse, and may do so as soon as they reach adulthood. All individuals are assumed to be capable of dispersing throughout their lives. In our models, we assumed that all dispersal-mediated mortality is included in our general estimate of age-sex-specific mortality. Therefore, we did not include any cost to dispersal as defined by increased mortality.

- Rates of dispersal: We assumed three different levels of dispersal, defined here as being from one single population to another single population: Low (one percent), Medium (four percent), and High (eight percent). Therefore, under a Low dispersal scenario, and given four total subpopulations per metapopulation, a total of three percent of the individuals are assumed to disperse away from any one subpopulation while 97 percent are assumed to remain in the subpopulation. We made no attempt at being spatially explicit in our estimates of dispersal distances, as we are currently not modeling precise examples of natural subpopulation aggregations on the southwestern U.S. landscape but are rather exploring the dynamics of somewhat more arbitrary Chiricahua leopard frog metapopulations in order to gain insight into management options required for persistence of local populations.

- Subpopulation size: We classified subpopulations as either Small (10 individuals), Medium (40 individuals), or Large (100 individuals). This range of sizes represents a reasonable description of the subpopulation types currently present across Chiricahua leopard frog habitat. Metapopulation models were constructed that differed in the distribution of various subpopulation types in an attempt to provide insight into the minimum subpopulation distribution type that would lead to an acceptable level of viability. As with all models, we assumed that the carrying capacity was equivalent to 1.6 times the initial subpopulation size.

- Drought regime: We modeled the following types of scenarios when incorporating drought into our metapopulation models:
  - No drought in any subpopulation
  - All Small populations experience the more severe lentic drought, while the Medium and Large populations experience the lesser lotic drought. This was used to simulate the higher risk posed by drought on the more ephemeral pond populations, while the larger subpopulations would perhaps be more resistant in spring-fed or lotic habitats.
  - All subpopulations experience lotic drought, with one of the Small populations showing full resistance to drought. This scenario type is used to simulate a more aggressive strategy of drought management.

Results of Simulation Modeling

Baseline simulation

Where appropriate, the results that are reported here for each modeling scenario include:

r_s (SD) – The mean rate of stochastic population growth or decline (standard deviation) demonstrated by the simulated populations, averaged across years and iterations, for all simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity.

$P(E)_{15/50/100}$ – Probability of population extinction after the specified time interval, determined by the proportion of 500 iterations within that given scenario that have gone extinct within the given time frame. "Extinction" is defined in the *VORTEX* model as the absence of either sex.
$N_{15/50/100}$ – Mean population size after the specified time interval, averaged across all simulated populations, including those that are extinct.

T(E) – The average time to population extinction, in years.

The set of demographic, genetic, and ecological input data that represents our best understanding of the life history of Chiricahua leopard frogs in the southwest United States is hereafter referred to as our *baseline model*. In this case, our baseline model simulates the predicted trajectory of a relatively large population of leopard frogs that is free of the impacts of drought and genetic sources of mortality (i.e., inbreeding depression). The results of this analysis are presented in Figure 1. The average population growth rate is 0.042, and the extinction probability over 100 years is 0.2 percent (0 percent over 15 years).

It is important to observe and appreciate the amount of annual variation in population size across the iterations. The initial size of our simulated population was 100 individuals, but the population fluctuates in size to a minimum of just 15 – 20 animals up to the maximum carrying capacity of 250 individuals. This is also reflected in the high standard deviation in baseline model stochastic growth rate (0.446). Even though our carrying capacity was set at 250 individuals, the imposition of density dependence in both reproductive success (metamorph production) and juvenile mortality generates a simulated population that stabilizes at approximately 165 individuals. Our description of density dependence is, therefore, having the desired effect of dampening the approach to carrying capacity.

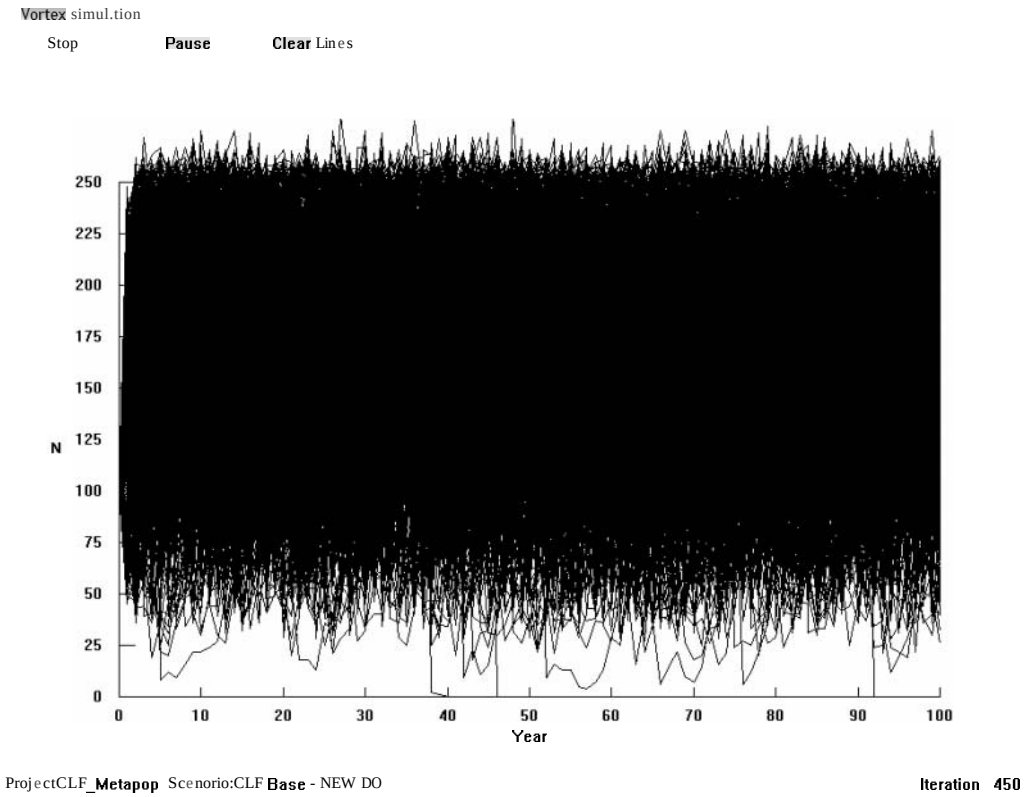


Figure 1. Plot of 500 individual iterations of the baseline *VORTEX* simulation model of Chiricahua leopard frog population dynamics. The average rate of population growth across these iterations is 0.042, with a very small risk of population extinction. Note the level of variance in the model's population growth rate as defined by both demographic and environmental sources of stochasticity. See text for accompanying details.

Our group thought that the simulation of leopard frog population dynamics was acceptably accurate, both in its mean trajectory and in its manifestation of annual variability in demography and subsequent population growth. We therefore felt comfortable with proceeding into the demographic sensitivity analysis phase of our work with the baseline model unchanged. It is important to note that, despite our sense of comfort with this model, we see this baseline projection as merely a starting point for deeper analysis of Chiricahua leopard frog population viability. In other words, we do not see this single model as precisely descriptive of the predicted fate of any one population or class of populations currently known to exist in the southwestern United States.

Generalized demographic sensitivity analysis

The results of our initial demographic sensitivity analysis are shown graphically in Figures 2a and 2b.

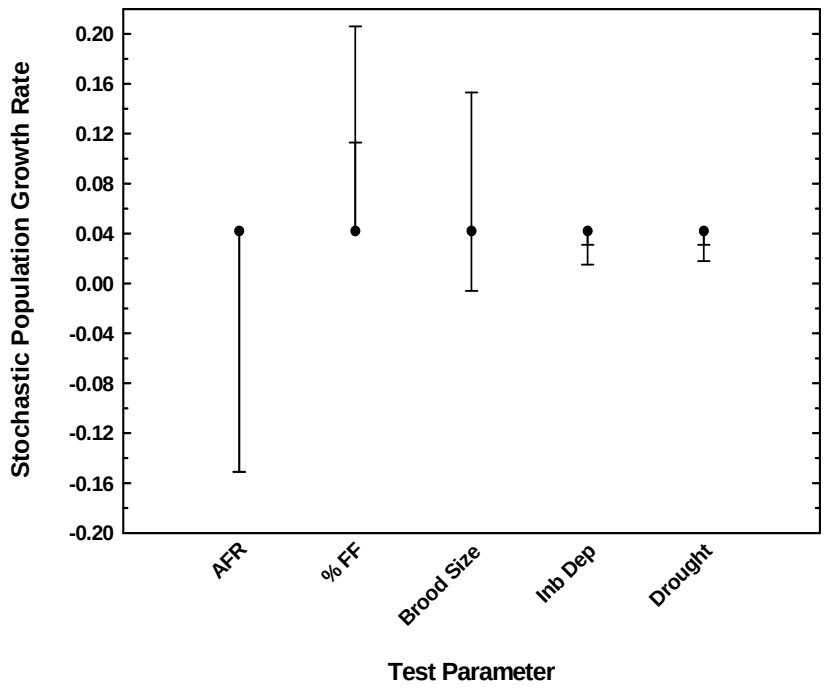


Figure 2a. Generalized demographic sensitivity analysis of a simulated Chiricahua leopard frog population. Stochastic population growth rate for a set of models in which the specific parameter is varied across a range of biologically plausible values. The baseline model growth rate of 0.042 is given by the central data point for each parameter. The general model of leopard frog population dynamics is most sensitive to uncertainty in those parameters giving the widest range in simulated population growth rates. See Table 2 for additional details.

Our initial analysis indicates that our model is highly sensitive to uncertainty in the age of first reproduction (AFR), female reproductive success (percent adult females producing metamorphs), and average brood size. While our estimate of the age of first reproduction may not have the same degree of uncertainty as other parameters analyzed here, it is instructive for our general understanding of leopard frog demography to observe the dramatic decrease in population growth brought about by a single year's delay in reproductive output for adult females. Given the rather high levels of mortality we see in this simulated population, a single year's delay in reproductive output decreases a given female's total reproductive potential by a sizeable amount. For example, the probability of a given female metamorph reaching five years of age is just 1.25 percent. Therefore, a delay in one year in reproductive ability will reduce her lifetime reproductive output by approximately 25 percent.

Using stochastic population growth rate as our metric to test model sensitivity may not give us the whole picture that can emerge from such an analysis. This is shown in Figure 2b, where we see that uncertainty in the type of drought affecting a given population may have a dramatic effect on the risk of population extinction – even if the overall effect on stochastic population growth rate is relatively minimal (Figure 2a). This result demonstrates the significant effect that a catastrophic event like drought can have on a population that is relatively stable in the long-term but is susceptible to periodic stochastic reductions in population size.

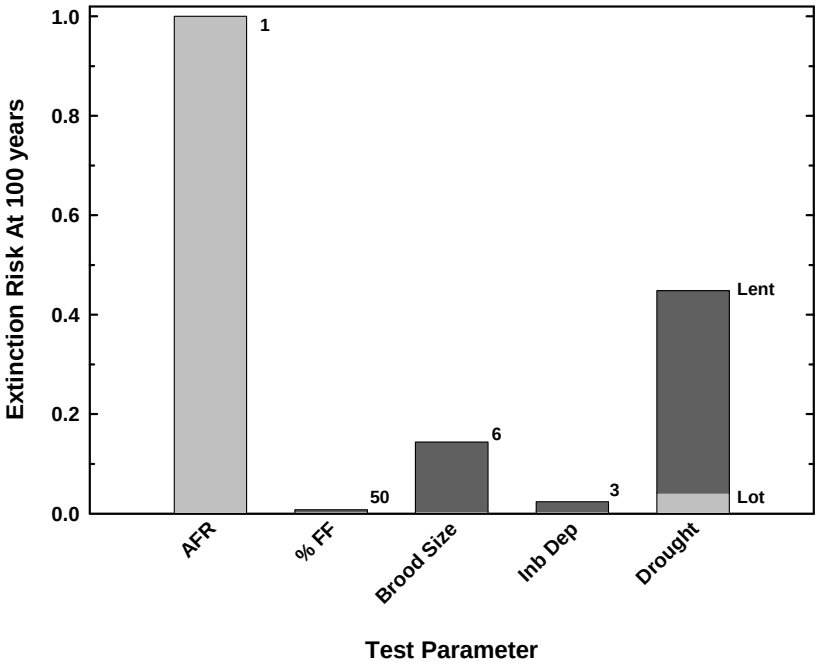


Figure 2b. Generalized demographic sensitivity analysis of a simulated Chiricahua leopard frog population. Probability of population extinction at 100 years for a set of models in which the specific parameter is varied across a range of biologically plausible values. Labels associated with each bar give the parameter values corresponding to the specific risk estimate. See Table 2 for additional details.

Mortality sensitivity analysis

We undertook a more detailed investigation of the sensitivity of our baseline model to changes in age-specific mortality rates and the magnitude of environmental variability (EV) around these rates. These results are shown in Figure 3.

When compared on a unit-change basis, our Chiricahua leopard frog model appears to be considerably more sensitive to uncertainty in juvenile mortality relative to adult mortality – both in terms of average stochastic population growth and in population extinction risk. This is generally the result with many “r-selected” species that are the subject of such an analysis, which reflects the large increase in overall population reproductive potential brought about by small changes in juvenile stage survival.

The results of this type of analysis help to identify the primary drivers of Chiricahua leopard frog population dynamics, and can assist in the prioritization of both research and management activities related to species conservation management. In this situation, broad management actions related to maximizing survival of juveniles can be viewed as priority recommendations. At a more detailed level, research directed towards better estimates of juvenile survival rates in the wild can help conservation biologists refine their models of Chiricahua leopard frog population biology, which will subsequently improve our ability to predict the response of populations to anthropogenic threats.

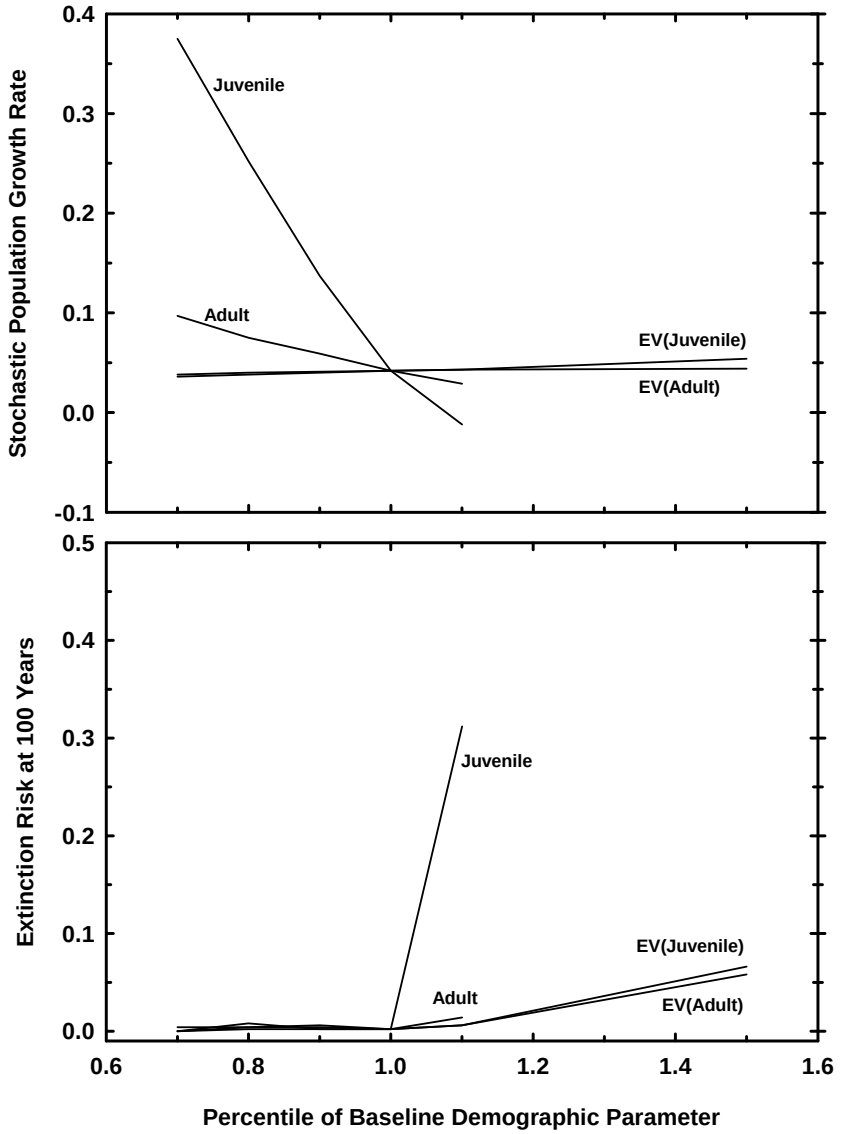


Figure 3. Mortality sensitivity analysis of a simulated Chiricahua leopard frog population in terms of stochastic growth rate (top) and probability of population extinction at 100 years (bottom). Values for age-specific mortality and associated environmental variability (EV) are varied in proportional units for more direct comparison of results. See Table 2 for additional details.

Risk analysis I: Population size, drought, and extinction risk

We were interested in looking at relative extinction risk as a function of population size, with and without the impact of catastrophic drought. This analysis may help us to identify a sort of population size threshold, below which the risk of extinction is likely to be unacceptably high. More specifically, we can begin to address the validity of the current definition of a "robust" leopard frog population.

To conduct this analysis, we developed a suite of models in which the baseline demographic parameters were employed, and then increased the initial population size from 10 to 100 in increments of 10. Out first set of ten models did not include drought. This first set of models was then repeated, but with the inclusion of a lotic-style drought. Next, a third set of models was

constructed where the lotic drought was replaced with a more severe lentic drought. Finally, this entire set of 30 models was itself repeated with the inclusion of inbreeding depression (arbitrarily set at 3.0 lethal equivalents) to test the impact of genetic instability on population viability.

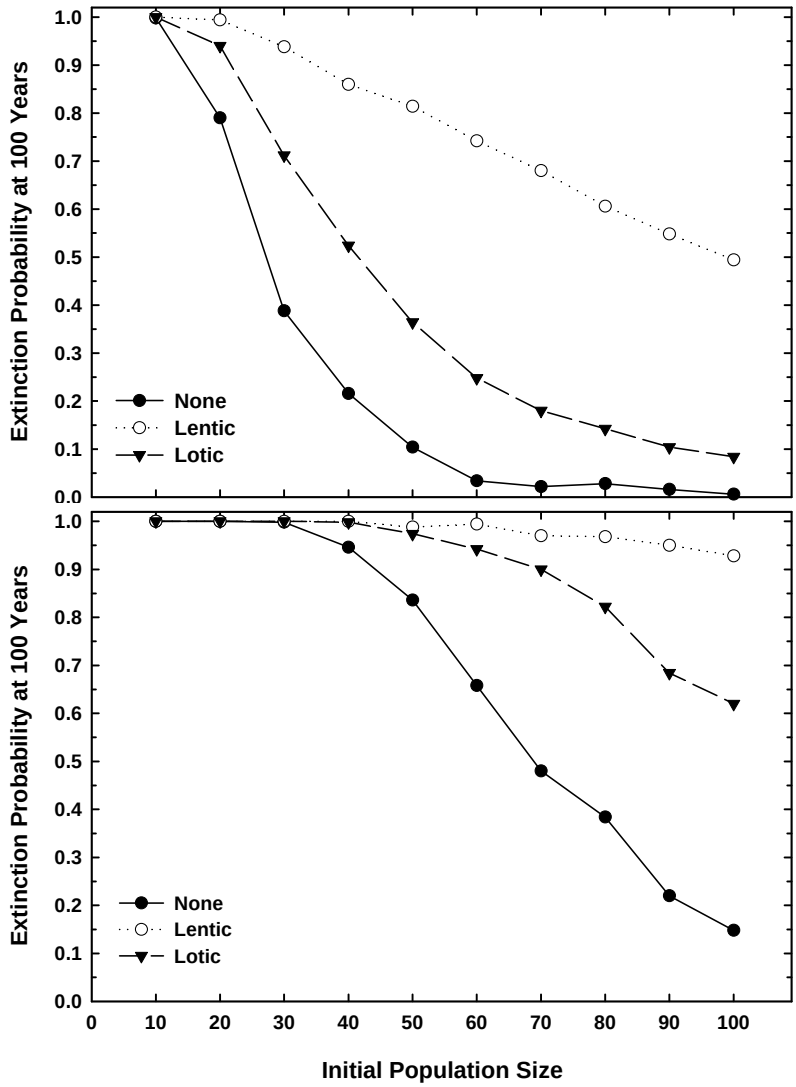


Figure 4. Risk analysis of a simulated Chiricahua leopard frog population. Extinction risk at 100 years as a function of initial population size and drought regime in the absence (top panel) or presence (bottom panel) of inbreeding depression for juvenile survival (3 lethal equivalents). See text for accompanying details.

The results of our risk analysis are presented graphically in Figure 4, in which the risk of population extinction is presented over the entire 100-year timeframe of the PVA simulation. In the absence of inbreeding depression, we can draw the following conclusions from these results:

- Immediately clear from these graphical results is the very high probability of extinction in the smallest populations (e.g., $N_0 \leq 20$ individuals), and the relative stability exhibited by populations starting with 60 or more individuals.
- The largest populations (e.g., $N_0 \geq 80$ individuals) appear to be largely unaffected by the less severe lotic drought. On the other hand, intermediate population sizes (e.g., $30 \leq N_0 \leq 70$) show a strong sensitivity to this event, with an often marked increase in extinction risk in the presence of this milder catastrophe.

- Lentic drought is seen to be a major catastrophic event. Even in the largest populations, extinction risk increases dramatically, with no discernible threshold effect with respect to population size.

When inbreeding depression is included in the model, nearly all populations are significantly affected. Only the largest populations in the absence of drought show little effect of this additional destabilizing force. Interestingly, we see a very dramatic change in the extinction risk profile under conditions of lotic drought: Even the largest populations show a large increase in extinction risk as inbreeding depression reduces overall population size to a point where periodic drought can render the population extinct with much greater frequency. This analysis demonstrates the common but complicated ways in which different processes can interact to put small populations of threatened wildlife at risk.

Of course, we have no data on the mode of action of inbreeding depression in wild Chiricahua leopard frog populations, or even if inbreeding depression exists at all. Therefore, we are unable to make specific predictions about the role this process plays in frog populations that exist currently. However, these analyses clearly demonstrate the additional risk that detrimental genetic processes can impose on small populations, and the sometimes subtle ways in which different processes whose individual impacts are relatively mild can interact to greatly increase extinction risk. Because of this, additional study of leopard frog population genetics may be warranted so that greater confidence can be placed on the inclusion of such factors into future PVA models.

Table 3 provides a more detailed look at the time course of extinction. These data are important as they help to evaluate the relative risk of extinction over a shorter time frame – in this case, we look at 15 and 50 years in addition to the standard 100-year timeframe. The 15-year period has been explicitly included in operational definitions of viability and recovery for Chiricahua leopard frogs. Note that the extinction risk increases over time, and the population size typically decreases as more extinctions occur over the time course of the computer simulation – even in the presence of a positive long-term stochastic growth rate. For example, a population initialized with 40 individuals in the absence of drought has only a 2.2 percent probability of extinction in 15 years, but this risk increases to 9.6 percent in 50 years and 21.6 percent in 100 years. The operation of stochastic demographic fluctuations serves to destabilize populations over time and therefore increases their risk of significant decline and possible extinction. When evaluating the results of population viability analyses, it is important to project far enough into the future so that processes with longer time horizons have a chance to influence the course of the projection. This is particularly important in this Chiricahua leopard frog analysis, where drought occurs on average only once in a 20-year period. A time horizon for analysis that is significantly shorter than this period will be unable to resolve the longer-term impacts of drought – an impact that we can see as profound indeed. While a time horizon of 100 years may in some instances be impractical for realistic management recommendations, it may be necessary to revise the timeframe definition of viability of Chiricahua leopard frog populations to longer than just 15 years.

Table 3. Results of Chiricahua leopard frog population size risk analysis models under different drought regimes. In all simulations, lotic drought is assumed to display only 50 percent of the severity of lentic drought. Extinction risk and population size estimates are given for 15, 50 and 100-year time periods. The rows with initial population size of 40 individuals are highlighted as this represents the current Recovery Plan definition for "robust" population. See page 9 for definitions of column headings.

N_0	Drought	r_s (SD)	P(E) 15 / 50 / 100	N 15 / 50 / 100	T(E)
10	None	0.028 (0.548)	0.584 / 0.966 / 0.998	4.25 / 0.37 / 0.01	16
20		0.028 (0.516)	0.184 / 0.512 / 0.790	16.16 / 10.32 / 4.48	41
30		0.034 (0.490)	0.054 / 0.194 / 0.388	30.57 / 25.68 / 18.68	50
40		**0.035 (0.484)**	**0.022 / 0.096 / 0.216**	**41.87 / 37.62 / 31.95**	**53**
50		0.037 (0.471)	0.010 / 0.056 / 0.104	52.95 / 49.26 / 46.36	52
60		0.039 (0.461)	0.006 / 0.016 / 0.034	63.54 / 62.87 / 61.32	51
70		0.038 (0.461)	0.002 / 0.008 / 0.022	75.14 / 72.87 / 70.54	53
80		0.037 (0.455)	0.008 / 0.018 / 0.028	84.95 / 79.56 / 84.25	39
90		0.038 (0.456)	0.000 / 0.006 / 0.016	94.78 / 94.99 / 92.88	59
100		0.038 (0.450)	0.000 / 0.002 / 0.006	107.14 / 105.35 / 110.12	53
10	Lotic	0.014 (0.561)	0.710 / 0.986 / 1.000	3.22 / 0.16 / --	13
20		0.008 (0.565)	0.310 / 0.762 / 0.940	13.44 / 4.80 / 0.82	30
30		0.017 (0.551)	0.140 / 0.438 / 0.712	24.54 / 15.95 / 8.18	43
40		**0.021 (0.544)**	**0.088 / 0.286 / 0.524**	**33.44 / 27.64 / 18.55**	**47**
50		0.021 (0.538)	0.072 / 0.200 / 0.364	43.22 / 38.18 / 30.76	46
60		0.023 (0.531)	0.032 / 0.140 / 0.248	55.88 / 47.64 / 43.02	48
70		0.025 (0.524)	0.014 / 0.098 / 0.180	65.64 / 61.09 / 56.52	49
80		0.027 (0.518)	0.022 / 0.086 / 0.142	74.99 / 71.17 / 69.07	46
90		0.027 (0.523)	0.016 / 0.048 / 0.104	85.14 / 82.24 / 75.57	56
100		0.027 (0.516)	0.010 / 0.036 / 0.084	97.22 / 93.41 / 90.11	52
10	Lentic	0.010 (0.563)	0.740 / 0.994 / 1.000	2.68 / 0.09 / --	11
20		0.002 (0.587)	0.446 / 0.926 / 0.994	10.86 / 1.46 / 0.09	21
30		0.004 (0.608)	0.368 / 0.790 / 0.938	17.83 / 5.78 / 1.72	28
40		**0.005 (0.628)**	**0.256 / 0.648 / 0.860**	**27.37 / 12.97 / 4.85**	**35**
50		0.006 (0.626)	0.218 / 0.560 / 0.814	37.04 / 19.86 / 8.51	38
60		0.006 (0.631)	0.136 / 0.476 / 0.742	46.16 / 28.13 / 12.79	42
70		0.009 (0.632)	0.132 / 0.400 / 0.680	58.53 / 38.16 / 22.02	44
80		0.008 (0.636)	0.110 / 0.368 / 0.606	64.08 / 45.67 / 29.03	44
90		0.011 (0.627)	0.088 / 0.314 / 0.548	72.20 / 58.88 / 38.18	47
100		0.012 (0.631)	0.078 / 0.290 / 0.494	78.66 / 64.51 / 45.65	45

Note that a population initiated with 40 individuals shows a minimum level of extinction risk in the absence of drought, as expected. This risk increases as drought severity increases and over the time period of the simulation. What may appear to be relatively immune from extinction in 15 years shows a considerably higher risk over longer time periods. The time course of extinction under the three drought regimes for a population initiated with 40 individuals is shown in Figure 5.

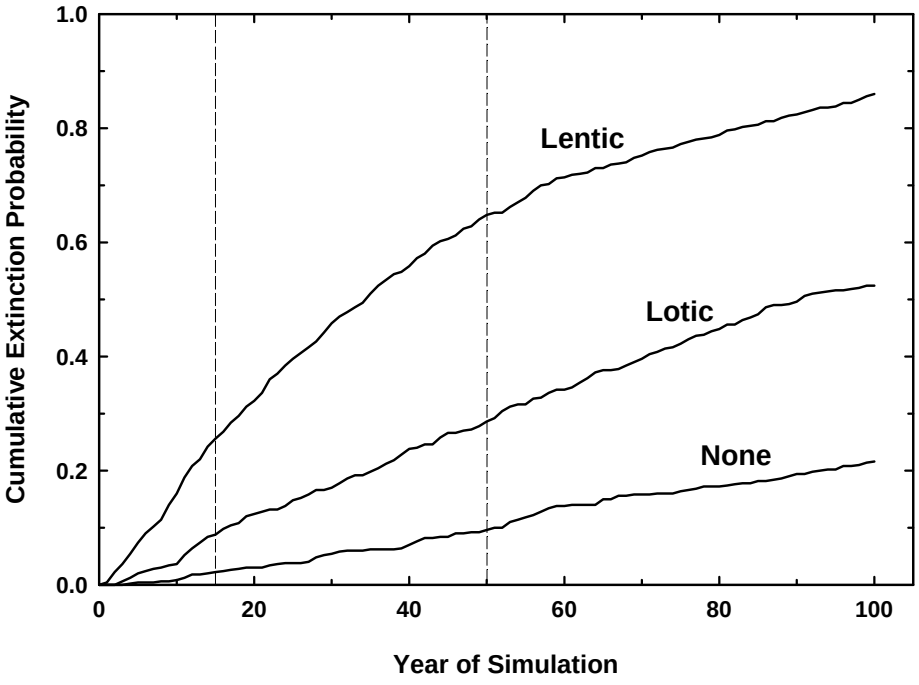


Figure 5. Cumulative population extinction risk as a function of time for a simulated Chiricahua leopard frog population initiated with 40 individuals and subjected to three different drought regimes. The vertical dashed lines correspond to 15 and 50 years of elapsed time in the simulation. See text for accompanying details.

Risk analysis II: Metapopulation viability

In order to be "recovered" under the conditions set forth in the Draft Chiricahua Leopard Frog Recovery Plan, the species "…must reach a population level and have sufficient habitat to provide for the long-term persistence of metapopulations in each of the eight recovery units (RUs), even in the fact of local losses (e.g., extirpation)." Given this recovery goal, a population viability analysis must consider selected elements of metapopulation dynamics in the context of Chiricahua leopard frog persistence.

To begin our metapopulation analysis, we wanted to investigate the relative importance of increasing subpopulation size as compared to increasing rates of dispersal between subpopulations as a means of increasing the likelihood of metapopulation persistence, given a constant number of subpopulations per metapopulation. We therefore constructed a set of models with the following characteristics:

- Each metapopulation consisted of four subpopulations, and each subpopulation was initialized with 10, 40, or 100 individuals (giving a total metapopulation size of 40, 160, or 400). Carrying capacity was equal to 1.6 times initial population size in all cases.
- For each metapopulation, dispersal rates were fixed at one, four, or eight percent between any one subpopulation and each of its neighbors. Therefore, the total dispersal rate for any one subpopulation was three, 12, or 24 percent for any one specific dispersal scenario.

- Drought was either absent or present for any given scenario. When present, we randomly selected two populations to experience a more severe lentic drought, while the other two populations suffered through a milder lotic drought. Because the metapopulation as a whole was symmetric with respect to both subpopulation size and dispersal rates, the choice of drought regime for a given subpopulation was arbitrary. The intent here was to simulate some systems within a metapopulation that would be, through natural or artificial means, differentially resistant to a given drought event.

This combination of characteristics yielded 18 different scenarios for analysis. The results of our models are presented in Figure 6 and Table 4.

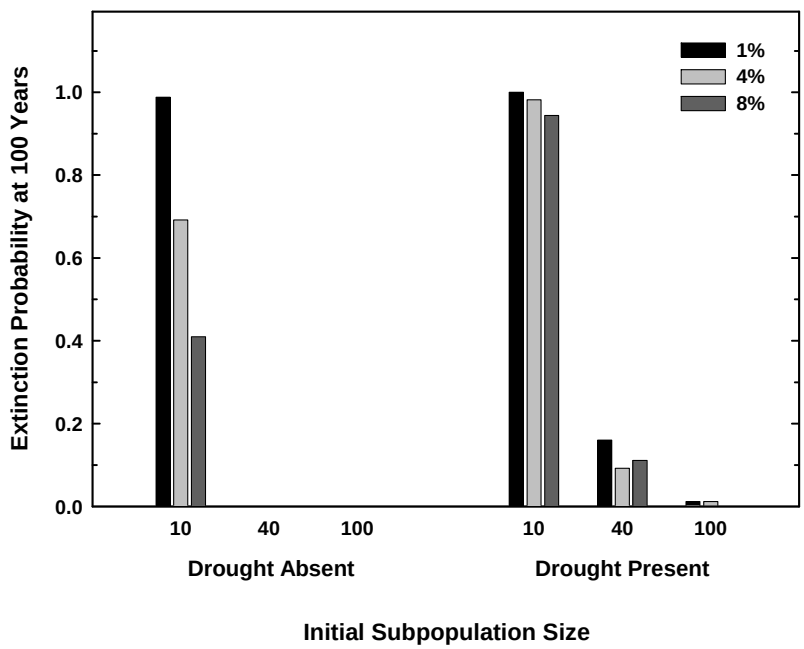


Figure 6. Metapopulation risk analysis for Chiricahua leopard frogs. Extinction risk at 100 years as a function of initial subpopulation size and dispersal rates in the absence (left-hand group of bars) or presence (right-hand group of bars) of drought. See text for accompanying details.

Once again, these results reinforce the severe impact that drought – of even a relatively milder form when lotic drought is included here – can have on the viability of small leopard frog populations. However, of greatest importance in this analysis is the dramatic effect of increasing subpopulation size when compared to increases in dispersal rate. In the absence of drought, an eight-fold increase in dispersal frequency in a metapopulation composed solely of the smallest subpopulations (N_0 = 10) shows a fairly significant reduction in the risk of overall metapopulation extinction within 100 years (left-most set of bars, Figure 6). But just a four-fold increase in the initial size of each metapopulation to 40 individuals, even under conditions of low dispersal frequency, eliminates extinction risk completely. Although the identical risk is not eliminated completely in the presence of mixed drought, the effect of increasing subpopulation size remains substantial (right-hand set of bars, Figure 6). Taken together, these results suggest that overall metapopulation stability may be more closely linked to the size of each component subpopulation, and less to the degree of connectivity between them.

Table 4. Results of Chiricahua leopard frog metapopulation risk analysis models. Each metapopulation was initialized with four subpopulations of the specified size, and differential dispersal between each subpopulation ranged from 1 percent to 8 percent. When drought was present, two subpopulations were assigned the more severe lentic drought, while the remaining two subpopulations were subjected to the milder lotic drought. All P(E) and N results are for the metapopulation as a whole. The bold line of data refers to discussion in the accompanying text. See page 9 for definitions of column headings.

$N_{0,i}$	Dispersal	r_s (SD)	P(E) 15 / 50 / 100	N 15 / 50 / 100	T(E)
Drought Absent					
10	1 percent	0.007 (0.441)	0.124 / 0.756 / 0.988	20.85 / 4.12 / 0.18	37
40		0.055 (0.301)	0.000 / 0.000 / 0.000	167.84 / 170.87 / 168.27	–
100		0.051 (0.293)	0.000 / 0.000 / 0.000	441.82 / 434.14 / 430.64	–
10	**4 percent**	**0.027 (0.380)**	**0.088 / 0.432 / 0.692**	**29.48 / 18.32 / 10.03**	**45**
40		0.048 (0.304)	0.000 / 0.000 / 0.000	174.29 / 174.46 / 174.94	–
100		0.045 (0.295)	0.000 / 0.000 / 0.000	450.91 / 446.26 / 458.51	–
10	8 percent	0.038 (0.357)	0.036 / 0.190 / 0.410	35.99 / 30.35 / 22.60	54
40		0.041 (0.305)	0.000 / 0.000 / 0.000	181.91 / 180.47 / 178.34	–
100		0.038 (0.297)	0.000 / 0.006 / 0.000	464.19 / 461.17 / 459.35	–
Drought Present					
10	1 percent	-0.028 (0.511)	0.342 / 0.944 / 1.000	13.15 / 0.73 / –	23
40		0.030 (0.459)	0.022 / 0.074 / 0.160	135.60 / 117.37 / 104.50	55
100		0.036 (0.442)	0.004 / 0.012 / 0.012	368.22 / 370.14 / 355.47	29
10	4 percent	-0.020 (0.487)	0.288 / 0.834 / 0.982	20.37 / 4.21 / 0.59	30
40		0.031 (0.451)	0.004 / 0.046 / 0.092	148.94 / 143.04 / 132.95	50
100		0.031 (0.449)	0.002 / 0.002 / 0.012	389.42 / 386.40 / 377.25	59
10	8 percent	-0.012 (0.479)	0.025 / 0.726 / 0.944	25.17 / 9.96 / 1.50	34
40		0.026 (0.454)	0.004 / 0.056 / 0.112	155.27 / 145.75 / 143.21	52
100		0.027 (0.448)	0.000 / 0.000 / 0.002	407.52 / 391.73 / 401.99	97

The more detailed results in Table 4 once again emphasize the importance of looking at population viability beyond a simple 15-year time horizon. For example, in the absence of drought, a metapopulation composed of small subpopulations connected by four percent dispersal (the bold line in the Table) exhibits just 8.8 percent risk in 15 years – but this risk jumps to 43.2 percent in 50 years. The shorter time horizon might show a tolerable level of risk to the population manager, but this acceptance of risk ignores the danger looming in the coming decades.

Moreover, the results presented here suggest that a single population composed of 40 individuals is considerably more stable than four linked subpopulations of 10 individuals. The bold line in Table 4 shows a 43 percent probability of metapopulation extinction at 50 years when these small subpopulations are linked by an intermediate level of dispersal in the absence of drought. This can then be compared to a drought-free isolated population of 40 individuals that displays a 10 percent risk at the same time interval (see Figure 5). Even when linked together by significant dispersal, small populations cannot sustain themselves in the face of stochastic fluctuation in basic demographic determinants of population growth.

The intriguing results from this rather simple analysis led to the development of more sophisticated models, designed to shed some light on the conditions necessary to provide for some level of metapopulation stability. To address this question, we constructed four different population configurations:

A Three populations of 10 individuals, and one population of 40 individuals;
B Two populations of 10 individuals, and two populations of 40 individuals;
C One population of 10 individuals, and three populations of 40 individuals;
D One population of 10 individuals, two populations of 40 individuals, and one population of 100 individuals.

In addition, we constructed three different drought regimes:

- No – No drought;
- Lentic/Lotic – All populations of 10 individuals experience lentic drought, while the larger populations experience lotic drought. This is designed to simulate the natural tendency for the smaller populations to frequently occupy more ephemeral sites that are particularly prone to drought-induced desiccation;
- Lotic/Immune – All populations experience the milder lotic drought, with the exception of a single randomly-selected population of 10 individuals that is immune to the effects of drought. This regime is designed to simulate a more aggressive management regime where there is partial to full mitigation of the effects of drought, with the efficacy of mitigation largely determined by subpopulation size.

In addition, we assumed the standard levels of dispersal rate considered in earlier metapopulation viability models. This combination of characteristics yielded 36 different scenarios for analysis. The results of these analyses are presented in Figure 7 and Table 5.

In general, metapopulation configuration A shows the lowest degree of viability among all such configurations tested. This is not surprising, particularly in light of the results of the previous metapopulation analyses (Figure 6, Table 4). In the absence of drought, configurations B, C and D all show little to no extinction risk over the full 100 years of the simulation, with average annual population growth rates approaching 7.0 percent. These results serve to reinforce the conclusion reached in earlier analyses – very small populations, even when linked with relatively high levels of dispersal, will not be capable by themselves of maintaining overall metapopulation viability. Having said this, it may be possible to compose a metapopulation with enough small subpopulations and sufficiently high dispersal to attain an acceptable level of metapopulation viability. For example, if each subpopulation were linked to each of its neighbors with four percent dispersal probability, it would require eight subpopulations of 10 individuals to achieve a metapopulation extinction probability of 0.08 in the absence of drought (model results not presented elsewhere in this report). One must remember; however, that each of these subpopulations will become extinct numerous times during a 100-year simulation, with frequent recolonization from nearby subpopulations necessary to achieve metapopulation “stability” for a given period of time. This level of quasi-stability may not be sufficient within the bounds drawn up within the Chiricahua leopard frog Recovery Plan.

Table 5. Results of Chiricahua leopard frog metapopulation risk analysis models. For each of four different subpopulation configurations, models combined different levels of dispersal (D) with drought regime. All P(E) and N results are for the metapopulation as a whole. See page 9 for definitions of column headings, and accompanying text for more model details.

D (percent)	Drought	r_s (SD)	P(E) 15 / 50 / 100	N 15 / 50 / 100	T(E)
Metapopulation Type A: 3x10, 1x40					
1	None	0.044 (0.388)	0.014 / 0.076 / 0.190	60.84 / 52.95 / 48.14	57
4		0.055 (0.345)	0.004 / 0.044 / 0.082	67.78 / 63.61 / 61.59	48
8		0.065 (0.337)	0.002 / 0.014 / 0.040	66.01 / 64.88 / 63.65	62
1	Len/Lot	0.016 (0.502)	0.080 / 0.304 / 0.538	47.51 / 32.73 / 21.64	48
4		0.021 (0.479)	0.104 / 0.342 / 0.598	53.48 / 38.82 / 22.67	45
8		0.025 (0.483)	0.088 / 0.368 / 0.658	52.16 / 35.32 / 18.28	47
1	Lot/Imm	0.025 (0.449)	0.038 / 0.270 / 0.506	51.17 / 36.74 / 24.76	51
4		0.037 (0.405)	0.032 / 0.156 / 0.312	60.12 / 48.52 / 41.61	51
8		0.046 (0.387)	0.014 / 0.116 / 0.278	60.38 / 51.32 / 41.38	55
Metapopulation Type B: 2x10, 2x40					
1	None	0.052 (0.337)	0.000 / 0.004 / 0.024	99.19 / 95.04 / 92.52	64
4		0.057 (0.325)	0.000 / 0.000 / 0.002	102.12 / 101.95 / 99.63	89
8		0.069 (0.320)	0.000 / 0.000 / 0.002	97.49 / 99.13 / 97.62	56
1	Len/Lot	0.020 (0.507)	0.062 / 0.224 / 0.444	74.74 / 54.54 / 38.34	50
4		0.028 (0.487)	0.052 / 0.202 / 0.382	79.40 / 66.56 / 50.97	49
8		0.033 (0.494)	0.062 / 0.272 / 0.466	78.39 / 59.17 / 46.16	48
1	Lot/Imm	0.035 (0.417)	0.010 / 0.076 / 0.208	85.50 / 74.20 / 61.80	60
4		0.045 (0.387)	0.006 / 0.026 / 0.068	89.01 / 86.62 / 83.33	59
8		0.056 (0.380)	0.012 / 0.042 / 0.074	88.45 / 83.05 / 40.61	51
Metapopulation Type C: 1x10, 3x40					
1	None	0.054 (0.318)	0.000 / 0.000 / 0.002	132.58 / 132.53 / 134.42	78
4		0.054 (0.312)	0.000 / 0.000 / 0.000	135.68 / 136.93 / 137.63	–
8		0.060 (0.314)	0.000 / 0.000 / 0.000	136.74 / 135.60 / 135.62	–
1	Len/Lot	0.022 (0.503)	0.034 / 0.166 / 0.342	99.29 / 79.80 / 64.80	53
4		0.027 (0.493)	0.044 / 0.148 / 0.306	112.26 / 94.60 / 78.90	52
8		0.032 (0.497)	0.032 / 0.172 / 0.328	105.99 / 95.17 / 75.60	52
1	Lot/Imm	0.039 (0.394)	0.002 / 0.040 / 0.082	115.63 / 107.68 / 99.64	52
4		0.044 (0.380)	0.002 / 0.008 / 0.016	125.48 / 122.18 / 123.71	53
8		0.051 (0.375)	0.002 / 0.006 / 0.018	124.89 / 119.95 / 122.37	54
Metapopulation Type D: 1x10, 2x40, 1x100					
1	None	0.052 (0.326)	0.000 / 0.000 / 0.000	201.55 / 198.01 / 198.54	–
4		0.059 (0.319)	0.000 / 0.000 / 0.000	200.70 / 196.82 / 199.95	–
8		0.074 (0.314)	0.000 / 0.000 / 0.000	191.66 / 189.10 / 190.72	–
1	Len/Lot	0.033 (0.475)	0.004 / 0.028 / 0.066	159.82 / 159.49 / 150.65	54
4		0.040 (0.467)	0.008 / 0.042 / 0.080	164.36 / 165.71 / 147.31	49
8		0.051 (0.470)	0.010 / 0.066 / 0.134	162.91 / 152.28 / 135.01	53
1	Lot/Imm	0.041 (0.400)	0.000 / 0.006 / 0.012	180.84 / 177.36 / 174.17	51
4		0.048 (0.389)	0.002 / 0.006 / 0.016	176.43 / 174.44 / 182.63	57
8		0.062 (0.380)	0.000 / 0.002 / 0.004	171.33 / 169.42 / 166.17	64

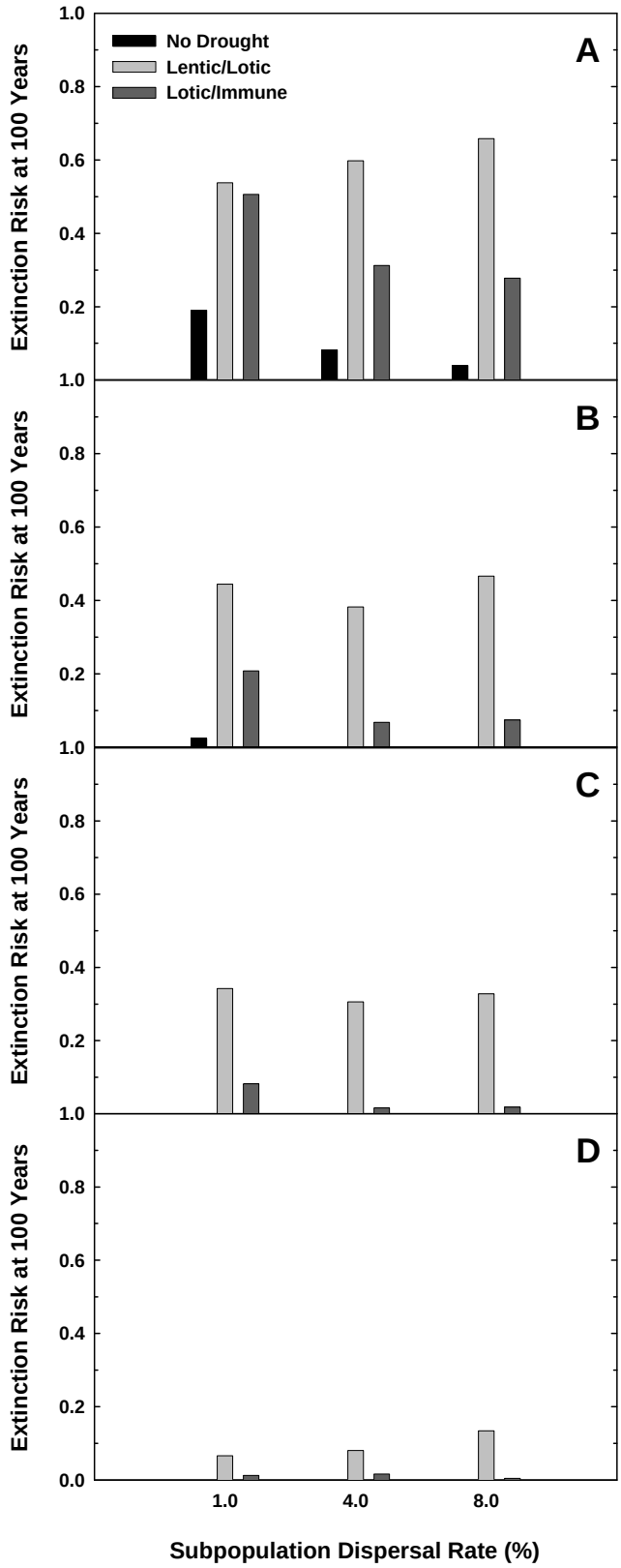


Figure 7. Metapopulation risk analysis for Chiricahua leopard frogs. Extinction risk at 100 years as a function of metapopulation configuration and dispersal rates under three different drought regimes. Metapopulation configurations, defined as number of individuals per subpopulation, include:
A – 3 x 10, 1 x 40;
B – 2 x 10, 2 x 40;
C – 1 x 10, x 0;
D – 1 x 10, 2 x 0, 1 x 100.
"Lentic/Lotic" drought simulates lentic drought conditions among the smallest subpopulations and lotic drought among the remaining larger subpopulations. "Lotic/Immune" drought simulates lotic drought in all subpopulations with one small population immune from drought through active habitat management. See text for accompanying details.

Deeper analysis of the results in Figure 7 and Table 5 reveal interesting evidence of source-sink dynamics in selected metapopulations. For example, a look at panel A in Figure 7 shows that in the case of the lentic/lotic drought regime, an increase in the dispersal rate actually leads to an **increase** in the metapopulation extinction risk. In this configuration, the smallest populations are being driven to rapid extinction by a combination of stochastic small population dynamics and drought. The single medium-sized population then supplies individuals to these smaller populations for local subpopulation re-establishment, but the smaller recipient subpopulations are not able to supply dispersers to bolster the number of individuals in the larger subpopulation. In other words, the smaller populations become demographic "sinks" to the medium-sized population "source". This same phenomenon is seen to a lesser degree in metapopulation configuration D where, under conditions of lentic/lotic drought, the single large subpopulation of 100 individuals plays the role of source to the smaller demographic sinks to which it is linked through dispersal. When the subpopulations are more evenly matched in size, as in metapopulation configurations B and C, these types of more complicated dynamics are less obvious to detect.

Overall, inspection of these results indicates that, within the constraints of our best understanding of Chiricahua leopard frog population biology and ecology, metapopulations need to include at least one large, healthy subpopulation (e.g., at least 100 adults) in order to achieve an acceptable level of viability as a larger unit. If drought can be managed effectively so that small, lentic habitats have a good chance of persistence, overall metapopulation viability may be achievable with a smaller number of individuals per subpopulation (e.g., 40 – 50 adults).

Directions for Future PVA Efforts

As discussed earlier within this document, it is unwise to use the results of a population viability analysis by themselves to determine precise and quantitative recovery targets for endangered species conservation and the strategies necessary for their achievement. The uncertainties surrounding our understanding of Chiricahua leopard frog biology, genetics, and ecology are too great for such precise predictions to be made. Nevertheless, we can gain considerable insight into the *relative response* of different frog populations to human activities, and thereby gain insight into how to best manage these populations to achieve a given level of security.

Although we are satisfied with the insights gained from this preliminary analysis, there are other factors and processes we see as potentially important to the future viability of Chiricahua leopard frog populations, but were unable to include in the models discussed here. Their omission from the current analysis reflects our lack of basic understanding of the processes involved, and/or our inability to precisely measure their impacts on frog populations. Such processes or factors include:

Impacts of non-native predators

We are currently unable to quantify the effects of different densities of non-native predators on leopard frog mortality. We would like to be able to more adequately model this impact in different habitats to identify those that are at particular risk.

Impacts of disease (chytrid fungus)

Chytrid fungus infection is seen by many herpetologists as a primary factor in global amphibian decline, and all indications are that Chiricahua leopard frogs are not immune to its dangers. We are currently unable to precisely describe the mode of action of chytrid fungus on leopard frog populations, although we recognize that any level of infection is likely to be catastrophic to many populations. Given this recognition, detailed modeling of its ecology and quantitative impact on frog populations may not be necessary.

Additional catastrophic processes

Our group engaged in very preliminary discussions on the impacts of other natural processes on Chiricahua leopard frog populations. For example, there is some suggestion that severe floods may have catastrophic impacts on local populations, although we are currently unable to describe these processes and their consequences in sufficient detail.

Optimal augmentation strategies

In addition to natural means of population augmentation through dispersal, would it be possible to boost the viability of local populations through augmentation? What would be the source of such individuals? Which populations within a given metapopulation should be the targets of augmentation in order to achieve the highest levels of metapopulation stability? What should be the optimal frequency and extent of augmentation? What types (i.e., age classes) of individuals should be used for augmentation? These questions may be of critical importance to the proper management of Chiricahua leopard frog populations, but we were unable to properly address them in this analysis.

Subsequent analyses of Chiricahua leopard frog population viability would greatly benefit from detailed discussions of these factors, in addition to those that were identified in the current analysis as both important in their contribution to population stability, yet also uncertain in their measurement.

Conclusions

We may conclude our preliminary analysis of Chiricahua leopard frog population viability by returning to the original set of questions that provided the foundation for our study. As a prelude, however, it may be worthwhile to discuss the general concept of extinction risk analysis and its use in endangered population management. Without specific guidance from the Endangered Species Act on consistent and quantitative definitions of threatened species categories, individual Recovery Teams are left to develop their own definitions. In the case of the Chiricahua leopard frog, delisting may occur under the following conditions (text taken directly from the December 2004 internal draft Chiricahua leopard frog Recovery Plan):

> At least two metapopulations in different drainages (defined here as USGS 10-digit Hydrologic Units) plus at least one isolated and robust population in each Recovery Unit (RU) exhibiting long-term persistence. Evidence of long-term

> persistence will be provided via a scientifically acceptable population monitoring program for at least a 15-year period, which is approximately 8-12 generations of the Chiricahua leopard frog.

The analyses presented here suggest that a 15-year window of observation may be inadequate to demonstrate viability of a relatively small population or metapopulation of Chiricahua leopard frogs that can be negatively impacted by human activities across the landscape. This is largely due to the fact that some processes and their effects, such as drought, often occur on time scales that are longer than the monitoring period set forth by the recovery plan. Consequently, dynamic and largely unpredictable processes that are very important in determining longer-term population performance are not taken into account to the extent necessary when making a decision on whether or not a species can be suitable for recovery. [1]

Based on the above considerations, it may be recommended that specific and quantitative definitions of such important terms as "viability" and "robust population" be explicitly articulated within this species' Recovery Plan. These terms are often linked to risk assessments that stem directly from an analysis like a PVA. Such a process has been used very effectively by the IUCN in its global Red List assessment of threatened species (IUCN 2001; available online at www.iucn.org/themes/ssc/redlists/redlistcatsenglish.pdf).

In addition, it may be important to recognize that "long-term persistence", in and of itself, is not a satisfactory condition for population stability and, by extension, recovery. Persistence does not speak to the magnitude, variability, or even the average direction of change in abundance over time. As a result, a population may be present in a given locality for the required time interval, but may actually show a discernible negative trend in abundance. Such an observation clearly would not reasonably allow the taxon to be recovered. A revised definition of recovery that expands on the notion of long-term persistence – to include concepts related to sustained increases in population size as observed through intensive monitoring programs – may be in order.

- *What is our depth of understanding of the population biology of the Chiricahua leopard frog?*

  A significant amount of effort has gone towards developing a quantitative understanding of Chiricahua leopard frog biology and ecology. Because of this work, we were able to develop a detailed preliminary demographic model of frog demography that proved extremely useful in our analysis.

- *Based on this understanding, what do we see as the primary drivers of leopard frog population growth? To which parameters is our demographic model most sensitive?*

  Our demographic sensitivity analysis revealed that juvenile survivorship is an extremely important determinant of Chiricahua leopard frog population dynamics. As such, priority should be given to both additional research aimed at developing a better quantitative estimate of this parameter under a suite of different ecological settings, as well as to any management activity that would likely result in the reduction of natural or anthropogenic threats to

[1] The 15-year component of the delisting criteria was revised in the final Recovery Plan based on these results.

juvenile survival. Other factors demonstrating particular importance in our model were the extent of female reproductive success (defined here as the proportion of adult females that were able to produce metamorphs) and the average number of metamorphs per successful female.

- *How vulnerable are small, fragmented Chiricahua leopard frog populations to local extinction in the absence of demographic interaction with other populations?*

  Given our best estimates of Chiricahua leopard frog population biology and ecology, our models suggest that populations of fewer than 50 – 60 individuals are at a significantly elevated risk of extinction compared to larger populations. There appears to be a type of threshold effect at this population size, above which the risk of local population extinction remains low.

- *What is the relative risk to leopard frog population viability posed by drought in lentic vs. lotic habitats?*

  Overall, drought is seen as a potentially severe risk to Chiricahua leopard frog populations. In particular, frogs occupying lentic habitats may be at considerably greater risk of catastrophic population decline and extinction due to the more severe impact of drought in these more ephemeral habitats. As a result, it may be prudent to develop specific management actions that reduce drought risk in lentic habitats (e.g., stock tank connections to windmills or pipelines, stock tank deepening, berm repair, etc.).

- *Is the current Recovery Plan definition of a "robust population" adequate in terms of relative risk of population extinction?*

  Given the results discussed above, the current definition of a "robust population" may be inadequate in the context of population extinction risk. As discussed above, the current definition is highly subjective and is ultimately dependent on a more precise articulation of risk tolerance over a specific time frame. In the absence of such a definition, these preliminary analyses suggest that increasing the population size threshold to approximately 60 individuals may be more appropriate. This number represents the minimum necessary and may have to be set to a higher level if the impacts of drought or other threat factors are not adequately addressed. Note that this definition refers to an isolated population; when such a population is linked to neighboring populations through dispersal, the subpopulation size threshold could be reduced to 40 – 50 individuals under our current level of species biology and demography.

- *What are the relative levels of importance of subpopulation size and dispersal rate within a given metapopulation in terms of metapopulation viability?*

  Under the conditions modeled here, metapopulation stability is achieved much more effectively through increasing subpopulation size. Even when connectivity through dispersal is relatively low, larger subpopulations are relatively more immune to the destabilizing effects of stochastic demographic fluctuations. This increase in local subpopulation stability directly translates to a higher degree of overall metapopulation stability.

- *Under what set of subpopulation characteristics (e.g., population size, dispersal rates, management intensity) can we observe a functioning metapopulation?*

A precise answer to this question (and, to a similar degree, all of the previous questions discussed here) is highly dependent on the underlying demographics of the component subpopulations. Nevertheless, our analyses indicate that very small populations of Chiricahua leopard frogs can often act as demographic "sinks" – draining larger "source" populations of their animals without providing sufficient levels of reciprocal dispersal to achieve overall metapopulation stability. This "source – sink" dynamic can have marked negative consequences for metapopulation persistence. Moreover, this dynamic can be even more pronounced when catastrophic drought is present, through significantly increased risk of local extinction of the smallest populations.

Appendix to Simulation Modeling and Population Viability Analysis

A model is any simplified representation of a real system. We use models in all aspects of our lives, in order to: (1) extract the important trends from complex processes, (2) permit comparison among systems, (3) facilitate analysis of causes of processes acting on the system, and (4) make predictions about the future. A complete description of a natural system, if it were possible, would often decrease our understanding relative to that provided by a good model, because there is "noise" in the system that is extraneous to the processes we wish to understand. For example, the typical representation of the growth of a wildlife population by an annual percent growth rate is a simplified mathematical model of the much more complex changes in population size. Representing population growth as an annual percent change assumes constant exponential growth, ignoring the irregular fluctuations as individuals are born or immigrate, and die or emigrate. For many purposes, such a simplified model of population growth is very useful, because it captures the essential information we might need regarding the average change in population size, and it allows us to make predictions about the future size of the population. A detailed description of the exact changes in numbers of individuals, while a true description of the population, would often be of much less value because the essential pattern would be obscured, and it would be difficult or impossible to make predictions about the future population size.

In considerations of the vulnerability of a population to extinction, as is so often required for conservation planning and management, the simple model of population growth as a constant annual rate of change is inadequate for our needs. The fluctuations in population size that are omitted from the standard ecological models of population change can cause population extinction, and therefore are often the primary focus of concern. In order to understand and predict the vulnerability of a wildlife population to extinction, we need to use a model that incorporates the processes causing fluctuations in the population, as well as those that control the long-term trends in population size (Shaffer 1981). Many processes can cause fluctuations in population size: variation in the environment (such as weather, food supplies, and predation), genetic changes in the population (such as genetic drift, inbreeding, and response to natural selection), catastrophic effects (such as disease epidemics, floods, and droughts), decimation of the population or its habitats by humans, the chance results of the probabilistic events in the lives of individuals (sex determination, location of mates, breeding success, survival), and interactions among these factors (Gilpin and Soulé 1986).

Models of population dynamics that incorporate causes of fluctuations in population size in order to predict probabilities of extinction, and to help identify the processes contributing to a population's vulnerability, are used in "Population Viability Analysis" (PVA) (Lacy 1993/94). For the purpose of predicting vulnerability to extinction, any and all population processes that impact population dynamics can be important. Much analysis of conservation issues is conducted by largely intuitive assessments by biologists with experience with the system. Assessments by experts can be quite valuable, and are often contrasted with "models" used to evaluate population vulnerability to extinction. Such a contrast is not valid, however, as *any* synthesis of facts and understanding of processes constitutes a model, even if it is a mental model within the mind of the expert and perhaps only vaguely specified to others (or even to the expert himself or herself).

A number of properties of the problem of assessing vulnerability of a population to extinction makes it difficult to rely on mental or intuitive models. Numerous processes impact population dynamics, and many of the factors interact in complex ways. For example, increased fragmentation of habitat can make it more difficult to locate mates, can lead to greater mortality as individuals disperse greater distances across unsuitable habitat, and can lead to increased inbreeding, which in turn can further reduce ability to attract mates and to survive. In addition, many of the processes impacting population dynamics are intrinsically probabilistic, with a random component. Sex determination, disease, predation, mate acquisition -- indeed, almost all events in the life of an individual -- are stochastic events, occurring with certain probabilities rather than with absolute certainty at any given time. The consequences of factors influencing population dynamics are often delayed for years or even generations. With a long-lived species, a population might persist for 20 to 40 years beyond the emergence of factors that ultimately cause extinction. Humans can synthesize mentally only a few factors at a time, most people have difficulty assessing probabilities intuitively, and it is difficult to consider delayed effects. Moreover, the data needed for models of population dynamics are often very uncertain. Optimal decision-making when data are uncertain is difficult, as it involves correct assessment of probabilities that the true values fall within certain ranges, adding yet another probabilistic or chance component to the evaluation of the situation.

The difficulty of incorporating multiple, interacting, probabilistic processes into a model that can utilize uncertain data has prevented (to date) development of analytical models (mathematical equations developed from theory) that encompass more than a small subset of the processes known to affect wildlife population dynamics. It is possible that the mental models of some biologists are sufficiently complex to predict accurately population vulnerabilities to extinction under a range of conditions, but it is not possible to assess objectively the precision of such intuitive assessments, and it is difficult to transfer that knowledge to others who need also to evaluate the situation. Computer simulation models have increasingly been used to assist in PVA. Although rarely as elegant as models framed in analytical equations, computer simulation models can be well suited for the complex task of evaluating risks of extinction. Simulation models can include as many factors that influence population dynamics as the modeler and the user of the model want to assess. Interactions between processes can be modeled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programs, providing output that gives both the mean expected result and the range or distribution of possible outcomes. In theory, simulation programs can be used to build models of population dynamics that include all the knowledge of the system available to experts. In practice, the

models will be simpler, because some factors are judged unlikely to be important, and because the persons who developed the model did not have access to the full array of expert knowledge.

Although computer simulation models can be complex and confusing, they are precisely defined and all the assumptions and algorithms can be examined. Therefore, the models are objective, testable, and open to challenge and improvement. PVA models allow use of all available data on the biology of the taxon, facilitate testing of the effects of unknown or uncertain data, and expedite the comparison of the likely results of various possible management options.

PVA models also have weaknesses and limitations. A model of the population dynamics does not define the goals for conservation planning. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modeling can be used. Because the models incorporate many factors, the number of possibilities to test can seem endless, and it can be difficult to determine which of the factors that were analyzed are most important to the population dynamics. PVA models are necessarily incomplete. We can model only those factors that we understand and for which we can specify the parameters. Therefore, it is important to realize that the models probably underestimate the threats facing the population. Finally, the models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modeled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programs as needed (see Lacy and Miller 2002, Nyhus *et al*. 2002, and Westley and Miller 2003 for more details).

The *VORTEX* Population Viability Analysis Model

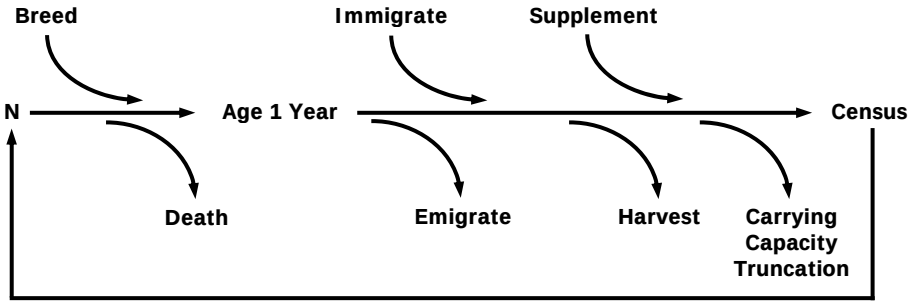
For the analyses presented here, the *VORTEX* computer software (Miller and Lacy 2003) for population viability analysis was used. *VORTEX* models demographic stochasticity (the randomness of reproduction and deaths among individuals in a population), environmental variation in the annual birth and death rates, the impacts of sporadic catastrophes, and the effects of inbreeding in small populations. *VORTEX* also allows analysis of the effects of losses or gains in habitat, harvest or supplementation of populations, and movement of individuals among local populations.

Density dependence in mortality is modeled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional mortality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified to change linearly over time, to model losses or gains in the amount or quality of habitat. Density dependence in reproduction is modeled by specifying the proportion of adult females breeding each year as a function of the population size.

VORTEX models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. During the simulation, *VORTEX* monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or “expected heterozygosity”) relative to the starting levels. *VORTEX* also

monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

VORTEX Simulation Model Timeline



Events listed above the timeline increase N, while events listed below the timeline decrease N.

VORTEX is an *individual-based* model. That is, *VORTEX* creates a representation of each animal in its memory and follows the fate of the animal through each year of its lifetime. *VORTEX* keeps track of the sex, age, and parentage of each animal. Demographic events (birth, sex determination, mating, dispersal, and death) are modeled by determining for each animal in each year of the simulation whether any of the events occur. (See figure above.) Events occur according to the specified age and sex-specific probabilities. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

VORTEX requires a lot of population-specific data. For example, the user must specify the amount of annual variation in each demographic rate caused by fluctuations in the environment. In addition, the frequency of each type of catastrophe (drought, flood, epidemic disease) and the effects of the catastrophes on survival and reproduction must be specified. Rates of migration (dispersal) between each pair of local populations must be specified. Because *VORTEX* requires specification of many biological parameters, it is not necessarily a good model for the examination of population dynamics that would result from some generalized life history. It is most usefully applied to the analysis of a specific population in a specific environment.

Further information on *VORTEX* is available in Lacy (2000) and Miller and Lacy (2003).

Dealing with Uncertainty

It is important to recognize that uncertainty regarding the biological parameters of a population and its consequent fate occurs at several levels and for independent reasons. Uncertainty can occur because the parameters have never been measured on the population. Uncertainty can occur because limited field data have yielded estimates with potentially large sampling error. Uncertainty can occur because independent studies have generated discordant estimates. Uncertainty can occur because environmental conditions or population status have been changing over time, and field surveys were conducted during periods which may not be representative of long-term averages. Uncertainty can occur because the environment will

change in the future, so that measurements made in the past may not accurately predict future conditions.

Sensitivity testing is necessary to determine the extent to which uncertainty in input parameters results in uncertainty regarding the future fate of the pronghorn population. If alternative plausible parameter values result in divergent predictions for the population, then it is important to try to resolve the uncertainty with better data. Sensitivity of population dynamics to certain parameters also indicates that those parameters describe factors that could be critical determinants of population viability. Such factors are therefore good candidates for efficient management actions designed to ensure the persistence of the population.

The above kinds of uncertainty should be distinguished from several more sources of uncertainty about the future of the population. Even if long-term average demographic rates are known with precision, variation over time caused by fluctuating environmental conditions will cause uncertainty in the fate of the population at any given time in the future. Such environmental variation should be incorporated into the model used to assess population dynamics, and will generate a range of possible outcomes (perhaps represented as a mean and standard deviation) from the model. In addition, most biological processes are inherently stochastic, having a random component. The stochastic or probabilistic nature of survival, sex determination, transmission of genes, acquisition of mates, reproduction, and other processes preclude exact determination of the future state of a population. Such demographic stochasticity should also be incorporated into a population model, because such variability both increases our uncertainty about the future and can also change the expected or mean outcome relative to that which would result if there were no such variation. Finally, there is “uncertainty” which represents the alternative actions or interventions that might be pursued as a management strategy. The likely effectiveness of such management options can be explored by testing alternative scenarios in the model of population dynamics, in much the same way that sensitivity testing is used to explore the effects of uncertain biological parameters.

Results

Results reported for each scenario include:

Deterministic r – The deterministic population growth rate, a projection of the mean rate of growth of the population expected from the average birth and death rates. Impacts of harvest, inbreeding, and density dependence are not considered in the calculation. When $r = 0$, a population with no growth is expected; $r < 0$ indicates population decline; and $r > 0$ indicates long-term population growth. The value of r is approximately the rate of growth or decline per year.

The deterministic growth rate is the average population growth expected if the population is so large as to be unaffected by stochastic, random processes. The deterministic growth rate will correctly predict future population growth if: the population is presently at a stable age distribution; birth and death rates remain constant over time and space (i.e., not only do the probabilities remain constant, but the actual number of births and deaths each year match the expected values); there is no inbreeding depression; there is never a limitation of mates

preventing some females from breeding; and there is no density dependence in birth or death rates, such as a Allee effects or a habitat "carrying capacity" limiting population growth. Because some or all of these assumptions are usually violated, the average population growth of real populations (and stochastically simulated ones) will usually be less than the deterministic growth rate.

Stochastic r – The mean rate of stochastic population growth or decline demonstrated by the simulated populations, averaged across years and iterations, for all those simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity. Usually, this stochastic r will be less than the deterministic r predicted from birth and death rates. The stochastic r from the simulations will be close to the deterministic r if the population growth is steady and robust. The stochastic r will be notably less than the deterministic r if the population is subjected to large fluctuations due to environmental variation, catastrophes, or the genetic and demographic instabilities inherent in small populations.

P(E) – The probability of population extinction, determined by the proportion of, for example, 500 iterations within that given scenario that have gone extinct in the simulations. "Extinction" is defined in the VORTEX model as the lack of either sex.

N – The mean population size, averaged across those simulated populations that are not extinct.

SD(N) – The variation across simulated populations (expressed as the standard deviation) in the size of the population at each time interval. SDs greater than about half the size of mean N often indicate highly unstable population sizes, with some simulated populations very near extinction. When SD(N) is large relative to N, and especially when SD(N) increases over the years of the simulation, then the population is vulnerable to large random fluctuations and may go extinct even if the mean population growth rate is positive. SD(N) will be small and often declining relative to N when the population is either growing steadily toward the carrying capacity or declining rapidly (and deterministically) toward extinction. SD(N) will also decline considerably when the population size approaches and is limited by the carrying capacity.

H – The gene diversity or expected heterozygosity of the extant populations, expressed as a percent of the initial gene diversity of the population. Fitness of individuals usually declines proportionately with gene diversity (Lacy 1993), with a 10 percent decline in gene diversity typically causing about 15 percent decline in survival of captive mammals (Ralls *et al.* 1988). Impacts of inbreeding on wild populations are less well known, but may be more severe than those observed in captive populations (Jiménez *et al.* 1994). Adaptive response to natural selection is also expected to be proportional to gene diversity. Long-term conservation programs often set a goal of retaining 90 percent of initial gene diversity (Soulé *et al.* 1986). Reduction to 75 percent of gene diversity would be equivalent to one generation of full-sibling or parent-offspring inbreeding.

APPENDIX D

Guidelines for Establishing and Augmenting Chiricahua Leopard Frog Populations, and for Refugia and Holding Facilities

Reestablishment, Establishment, and Augmentation of Chiricahua Leopard Frog Populations

As discussed in "**Population Trends and Distribution"** in Part I, the Chiricahua leopard frog has been eliminated from many localities, river drainages, and regions. In other areas it is represented by only one or two small populations in a mountain range or river basin. The distances and arid landscapes between extant populations and formerly occupied habitats are often too great to expect frogs to recolonize these areas on their own. Furthermore, where only small isolated populations exist, the species is likely to disappear in the near future due to demographic stochasticity or environmental disasters such as drought, flood, and fire. Small populations may also experience low genetic variability, which is a concern because in such populations deleterious alleles are expressed more frequently, disease resistance might be compromised, and there is little capacity for evolutionary change in response to changes in the environment.

To recover the species, active population management will be needed to translocate frogs to existing, restored, or created suitable habitats in a number and distribution that will promote long-term population or metapopulation stability in each RU. In the case of small, isolated populations, actions will often be needed to ensure persistence, and may include actions to increase carrying capacity through habitat enhancement, or augmentation of frog numbers or genetic diversity, particularly after drought, floods, or other events that reduce population size. The descriptions of the RUs in Appendix B include a discussion of MAs where recovery, including active population management, will be focused.

Our understanding of genetic differentiation within the Chiricahua leopard frog is incomplete; although northern (Mogollon Rim and west-central New Mexico) and southern populations (southeastern Arizona, southwestern New Mexico, and Mexico) exhibit differences that may be at the species level (Platz and Grudzein 1999). Other work also indicates intraspecific variation (Benedict and Quinn 1999, Goldberg *et al.* 2004, Hillis and Wilcox 2005). As a result, sources of frogs for translocations should preferably come from the next nearest location within (in order of preference) the MA, the RU, and an adjacent RU. Frogs should not be moved between northern and southern populations or localities.

The number and distribution of populations needed for long-term persistence will vary with conditions in each RU. Large, stable populations are likely to persist longer than small populations in dynamic habitats, such as livestock tanks. RUs that include large, stable populations may require relatively few populations to meet the recovery criteria, particularly if frogs are able to move among such populations, or from these populations to smaller "satellite" populations within reasonable dispersal distance. Efficient recovery will often involve building upon existing populations by establishing nearby frog populations in suitable habitats, including those that are restored or created in a cost-efficient manner. Habitat restoration or creation may

often serve a second purpose by providing water for other native fish and wildlife as well as livestock.

Diseases are more easily spread among populations within a metapopulation. As a result, metapopulations can be rapidly devastated by chytridiomycosis or other amphibian diseases (Scott 1993). Metapopulations that occur entirely in one drainage can also be devastated by environmental disasters, such as flooding or severe erosion and sedimentation following fires in the watershed. As a result, a single metapopulation, particularly in one drainage, will not be adequate for long-term persistence of the frog in a RU. More than one metapopulation in different drainages of a RU are needed for long-term persistence of the frog. An additional isolated but robust and stable population in another drainage within the RU is needed as well, as a further buffer against disease. Captive or actively managed wild or semi-wild refugial populations may be desirable for RUs in which regional or RU extirpation is likely in the near future. Refugia can provide assurance that all frogs from a MA or RU will not be lost due to disease or environmental disaster.

The following ranking factors will be used to identify sites where currently unoccupied habitats could be secured, restored, and/or created, and frog populations established or reestablished within the MAs identified in Appendix B. Sites best matching the ranking factors should be considered first for management, but other site-specific factors can be used as well. Isolated sites will be ranked somewhat differently from those within metapopulations. Note that "secondary sites", discussed in Part III of Appendix A, can be useful for enhancing dispersal or can serve as breeding sites in wet years (but do not count as "local populations" in a metapopulation). Refer to Appendix A for information about establishing these secondary sites.

Factors to be Considered in Identifying Sites for Recovery and Population Establishment:

Sites considered for recovery should provide or have the potential to provide, through habitat restoration or creation, "suitable" habitat for a population of at least, on average, 60 adult Chiricahua leopard frogs, or 40-50 adult frogs if the site exhibits some resistance to drought. Suitability is defined in the glossary (Appendix K), and further described in "Habitat Characteristics/Ecosystems" in Part 1; and Attachment 1 of Appendix E. Recovery project sites where frog populations will be established should ideally be at or near historical Chiricahua leopard frog localities. Although this is not a hard and fast rule, sites that historically supported the species should, if habitats are still suitable, be capable of supporting them again. Each potential establishment site should be carefully evaluated for potential effects to other native species. Chiricahua leopard frogs could compete with or prey upon other sensitive species, such as native fishes or other native frogs. Restoration of habitat (e.g. removal of non-natives, deepening a pond, etc) that may occur prior to population establishment could also have significant adverse effects to native species. These adverse effects need to be carefully weighed against the benefits of establishing or resestablishing a frog population.

Potential recovery and population establishment sites within a metapopulation should be within dispersal distance of other recovery sites or extant populations. Reasonable dispersal distance is generally one mile overland, three miles along intermittent drainages, or five miles along permanent water courses, or some combination thereof (see review in "Dispersal and

Metapopulation Ecology" in Part 1). Consideration should be given to barriers (cliff faces, urban areas, etc.) in determining the potential for movement of frogs. Some types of barriers can be mitigated, such as providing fencing and culverts under highways (see Appendix I). Within the reasonable dispersal distances, the closer a site is to an extant population or populations, the more desirable it is as a recovery project site within a metapopulation. However, sites in adjacent drainages should be given high priority as well because populations distributed among drainages may buffer the metapopulation against environmental disasters. Isolated, but large, stable habitats that can support robust populations of frogs should also be considered outside of metapopulations or with minimal connections to other populations, as a refuge in case of disease.

The size of the potential recovery project site and its stability as frog habitat are other important considerations. Large, stable habitats can support relatively large populations that may persist for a long time, even without immigration from other populations. Habitat complexity (e.g. variety of aquatic habitats, bankline vegetation, rocks, and other substrates, etc.) and presence of abundant deep, permanent or semi-permanent pools are important for long-term population persistence, as well. Permanent water is desirable, but some habitats that dry out periodically can be important too, as drying will eliminate some non-native predators but may not eliminate leopard frogs, particularly if recolonization can occur from adjacent populations. Sites that dry out most years for a month or more will not provide important breeding habitat, but could be used for breeding during wet periods or as a stepping stone for dispersing frogs (see "secondary sites" in Part III, Appendix A).

From a practical standpoint, recovery sites that require no or minimal site preparation prior to re-translocation of frogs are preferred over sites that will require expensive habitat work. For instance, removal of non-native predators will not be practical in many large or complex aquatic systems that support multiple, abundant non-native species – these systems should probably not be considered for restoration unless new techniques for non-native control are developed (this is particularly true for hard-to-manage non-natives such as American bullfrogs and crayfish). Exceptions to this general rule are habitats that are complex, but in which densities of non-native predators are low. In these situations, Chiricahua leopard frogs and low densities of non-natives can sometimes coexist. Simple systems, such as stock tanks, will often make good recovery candidates, regardless of non-natives, because these predators can be eliminated from simple systems (Rosen and Schwalbe 2000, Schwalbe *et al.* 2000). Recovery sites can be fenced to exclude invasion or reinvasion by American bullfrogs, but such fencing will also exclude immigration/emigration of leopard frogs, and should be considered only as a last resort. Such fencing may only be appropriate for establishment of captive refugia. A related concern is the likelihood of reinvasion of non-natives due to human introduction. Public access can potentially be limited, or outreach can be conducted to reduce the potential for reintroductions, but in some cases a site may be too popular as a fishing hole or recreation site to halt future stocking of non-natives. Such sites should not be considered for recovery.

Sites that require little maintenance or management are desirable as recovery sites. For example, natural systems that do not require fencing out of livestock, supplemental water, periodic removal of non-natives, etc. are most desirable. Aquatic sites supplied with water from windmills or solar pumps should be low priority unless staff is dedicated to monitoring and promptly fixing problems with these systems. Stock tanks filled by runoff require less

maintenance, but may need supplemental water hauled to them during drought, berms may need to be repaired after floods, and periodic dredging will often be needed to prevent them from silting in. Potential conflicts with water rights and existing or known future water diversions and uses should be minimized.

Generally, sites within reasonable dispersal distance of chytrid-positive populations of leopard frogs or other amphibians should only be considered as potential recovery sites if there is evidence that nearby chytrid-positive Chiricahua leopard frog populations are persisting and robust, despite the presence of the disease. Successful research into methods of eliminating chytrids from habitats (recovery action 7.3) would make sites near chytrid-positive populations more desirable for recovery.

NEPA, ESA, cultural resources, and other clearances or compliance will need to be accomplished prior to habitat restoration/creation and population establishment/reestablishment. If private landowners and/or water-rights holders are willing to allow establishment on their lands, it will often be desirable to develop Safe Harbor Agreements prior to population establishment. If through these processes, adverse effects to other natural or human resources are identified that cannot be mitigated, or costs associated with the compliance and any subsequent mitigation are excessive, recovery at that site should be abandoned or assigned a lower priority.

Finally, potential recovery sites should be given a high priority if they can serve as habitat for other sensitive, candidate, or listed species. Many Southwestern aquatic and wetland species are rare or threatened with extinction. Recovery projects that produce functional native, wetland ecosystems with abundant and diverse native floras and faunas can conserve a suite of native species that may further recovery of other listed species or help alleviate the need to list candidate or sensitive species. In selecting which other native species to include in recovery projects, consideration should be given to the potential for coexistence with Chiricahua leopard frogs. In simple systems such as stock tanks, chub (*Gila* sp.) or gartersnakes may be able to eliminate or severely reduce leopard frog populations; whereas in larger, more complex systems these species can coexist. Other native ranid frogs (e.g. northern, lowland, and plains leopard frogs and Tarahumara frog) may compete with and, in the case of the leopard frogs, potentially hybridize at low levels with Chiricahua leopard frogs; but creating some sites where more than one native ranid frog species exists would recreate historical conditions in which Chiricahua leopard frogs were not uncommonly sympatric with other native ranids.

Chiricahua Leopard Frog Refugia and Holding Facilities

Despite our best efforts, drought, disease, or other problems may result in extirpation of Chiricahua leopard frog populations from MAs or RUs before we can protect them. As a result, one or more captive or actively-managed refugium populations will often be desirable as a reservoir for genetic material, particularly in RUs where frogs are likely to be extirpated from a MA or the RU in the near future. Such refugia may also be desirable as a source of egg masses, tadpoles, and frogs for translocation to recovery sites, for augmentation, or to repopulate habitats after environmental disasters. Surplus frogs from these facilities may also be used for research

purposes (see recovery action 6). These populations would likely be small, captive populations, isolated from other frog populations, but could also be managed wild or semi-wild populations.

Also desirable are holding facilities that can be activated during drought, after fires in the watershed, or other disasters that threaten populations. Frogs may need to be temporarily captured and held in these holding facilities until ponds refill after drought or other threats abate or are corrected (see recovery action 1.2.14). As an example, Chiricahua leopard frogs were rescued from Walt's Tank in the Buckskin Hills of the Coconino Forest, when that tank dried out during the drought in 2002. The Arizona-Sonora Desert Museum held the frogs over the winter until the tank was refilled. The frogs were then repatriated.

Refugial populations and holding facilities may be located in wild or semi-wild managed aquatic habitats; or at zoos, museums, backyard ponds, fish hatcheries, or other similar facilities, which may or may not be located within the RU. The "ARIZONA LEOPARD FROG CAPTIVE CARE PROTOCOL" in Appendix F and "Guidelines for Backyard Chiricahua Leopard Frog Refugia" in Appendix J should be used to guide design of refugia/holding facilities and care of frogs. Refugia populations should be managed to ensure maintenance or enhancement of genetic diversity, including, for instance, isolating breeding pairs and periodically introducing new breeding stock. Disease prevention protocols (Appendix G) should be carefully followed to ensure operation of refugia and holding facilities does not result in spreading disease.

APPENDIX E

Survey and Preliminary Monitoring Protocols
- *Rana chiricahuensis* -
Survey Protocol for Project Evaluation

The following describes the survey protocol adopted by the USFWS, AGFD, and NMDGF. The purpose of the protocol is to detect Chiricahua leopard frogs where they occur and to, in some cases, confirm absence. Additional information is collected about habitats, associated organisms, and threats. Surveys conducted under a USFWS enhancement of survival (10a1A) permit must adhere to this protocol. We recommend its usage for monitoring Chiricahua leopard frog populations until a more comprehensive monitoring plan and schedule is developed (recovery action 5).

Permits/Certification

Surveyors must be permitted by the USFWS and the appropriate State agency. To obtain a permit, surveyors must attend USFWS/State approved certification training.

Procedure

Surveys shall include a night visit to all suitable habitats (see definition in Attachment 1) in the project's action area (the area affected directly and indirectly by the action). This will typically involve walking stream and river banks, along the edges of wet meadows, and around the perimeters of stock tanks and lakes in the action area. Surveys shall be carried out with flashlights/headlamps, and a dip net shall be used to sample for tadpoles and frogs concealed in undercut banks or at the base of emergent vegetation. Watch for frogs on banklines, but also floating in the water or visible on the bottom, and in areas away from water - particularly during or after rains. Surveyors shall also listen for the distinctive call of the Chiricahua leopard frog and watch for egg masses. Audible plops may indicate frogs are present, but their identity to species must be confirmed. Plops preceded by an escape call ("eeep") indicate American bullfrog presence. In order to survey when frogs are most active, surveys shall be carried out from April through September, and when water temperatures are at least 14°C at elevations below 5,500 feet and at least 12°C at 5,500 feet and above, and winds are light or absent. A diurnal survey can substitute for a nocturnal survey, but if frogs are not detected, surveyors should return at night. In simple habitats, such as typical livestock tanks with little or no bankline and emergent cover, 2 diurnal surveys carried out at least 3 hours after sunrise can substitute for a nocturnal survey. If surveyors have valid State and Federal permits for collecting, and populations appear large enough to sustain collection, a sample of up to 3 tadpoles should be collected as vouchers. Such a population is defined here as one in which 20 or more adult frogs are visible within 100 meters of shoreline or stock tank perimeter and tadpoles are visibly abundant. Surveyors should note observations of fishes to species, if possible, American bullfrogs, crayfish, salamanders, gartersnakes to species, and other native frogs. Additional information on how to survey sites is contained in Attachment 1 (General Visual Encounter Survey Method - AGFD). Data should be recorded on standard field survey

forms (Attachment 2), and data should be collected in accordance with the instructions for the form (Attachment 3).

Disease Prevention

To prevent inadvertent movement of disease or parasitic organisms among sites, surveys shall conform to Appendix G: Field Work Disease Prevention Protocol.

Survey Frequency

In simple habitats, such as stock tanks (not dry) with little or no bankline or emergent vegetation, a single nocturnal survey as described above will detect frogs, if they are present, over 90 percent of the time. Numbers of frogs detected are also likely a rough index of the relative abundance of frogs (Howland *et al.* 1997). If one nocturnal or two diurnal surveys of simple systems, such as typical livestock tanks with little or no bankline or emergent cover, are conducted and frogs are not detected, you may, for the purposes of section 7 consultation, conclude the species is absent. Negative survey results in complex habitats do not indicate with certainty the species is absent; however, if frogs are not detected, the species is likely rare or absent. In complex habitats, a case can be built for absence with repeated negative surveys, preferably over one or more seasons, as well as other information, such as absence of historic or recent records of the species at the project site and within reasonable dispersal distance[1], and/or that habitat suitability is marginal.

Site occupancy often changes, particularly at stock tanks or other small, dynamic aquatic systems. Some sites may only be used by transient frogs during wet periods. Frogs may be extirpated due to drought, floods, disease, or other factors. Isolated, small populations are particularly subject to extirpation and warrant more frequent surveys to assess current status. Larger populations in natural systems are less likely to be extirpated, and as a result, survey results and assessments of presence are valid for a longer period of time. Similarly, larger sites that are unoccupied due to presence of non-native predators are unlikely to be occupied in the foreseeable future and do not warrant frequent surveys.

Site occupancy can also change due to immigration and colonization, which may occur anytime during the warmer months (however, dispersal and colonization is most likely to occur during the summer monsoons). If extant populations occur within reasonable dispersal distance[1] of a site under assessment supporting suitable habitat, colonization is likely to occur and surveys more than once a year as part of project planning or BA/E preparation may be warranted to assess presence/absence. Surveys conducted in May or June, and then repeated after the monsoon season in September, can detect occupancy in both the permanently wet habitats and the seasonally colonized habitats. For long-term projects, such as 10-year grazing permits, you should assume frogs will colonize suitable habitats within reasonable dispersal distance during the life of the project. For short-term projects, surveys immediately prior to and possibly during construction or project implementation may be needed in habitats within reasonable dispersal distance of occupied sites to evaluate if frogs will be directly affected.

[1]Reasonable dispersal distance includes the following distances from occupied habitat to sites being evaluated for occupancy: a) within one mile overland, b) within three miles along an ephemeral or intermittent drainage, or c) within five miles along a perennial stream.

Ranid tadpoles can be identified using:

Scott, N.J., and R.D. Jennings. 1985. The tadpoles of five species of New Mexican leopard frogs. The Museum of Southwestern Biology, Occasional Papers 3:1-21.

Degenhardt, W.G., C.W. Painter, and A.H. Price. 1996. Amphibians and reptiles of New Mexico. University of New Mexico Press, Albuquerque. (See key by R. Altig at pages 15-16, and species accounts).

Recordings of the calls of Southwestern anurans, including the Chiricahua leopard frog, are found in:

Davidson, C. 1996. Frog and toad calls of the Rocky Mountains. Library of Natural Sounds, Cornell Laboratory of Ornithology, Ithaca, NY.

To identify Southwestern ranids and other anurans, see:

Degenhardt, W.G., C.W. Painter, and A.H. Price. 1996. Amphibians and reptiles of New Mexico. University of New Mexico Press, Albuquerque. (Especially see page 79, comparison of Southwestern leopard frogs).

ATTACHMENT 1

General Visual Encounter Survey Method
(Adapted from Arizona Game and Fish Department, May 2002)

This standard visual encounter survey (VES) method is to be used for Chiricahua leopard frog surveys. This method was adopted from Heyer *et al*. (1994) and modified based on statewide ranid surveys in Arizona. The method is designed to be simple and repeatable with minimal training of personnel. However, all personnel should be trained and have survey technique checked periodically by a more experienced individual. The VES method described here will generate presence/absence data if used independently and generate information from which inferences about abundance and trends can be made if used in a statistically valid monitoring program. Before designing a monitoring program, it is recommended that the user consult Gibbs' (1996) program MONITOR or Gerodette's (1987, 1993) program TRENDS to test the statistical power of the proposed monitoring program.

Equipment needed:

The observer should always have the following when conducting a VES:

- a dip net
- a Global Positioning System unit set to read in the North American Datum 1927 (NAD27Conus) and the appropriate Universal Transverse Mercator (UTM) Zone
- a clipboard with the Chiricahua leopard frog Survey Form and instructions
- a pen with waterproof ink
- a time piece with a stop watch
- a pH meter
- 2 thermometers
- a conductivity meter
- a sling psychrometer or hygrometer
- binoculars
- the appropriate United States Geologic Survey quadrangles
- bleach or Quat128 for disinfecting all gear before and after surveying each site

Other suggested items are the following:

- a counter or clicker for keeping a tally of frogs observed
- a field notebook
- a headlamp or spotlight for night surveys
- rubber boots, hip waders, or chest waders depending on the habitat
- guides to identification of aquatic insects, fish, amphibian larvae, and adult amphibians
- a digital or conventional camera with slide film
- the appropriate land ownership maps
- database reports of historic surveys done in the area
- wind meter
- measuring tape
- "dead box" (whirl pack or ziplock bags, MS 222, and formalin for collecting specimens)

- pocket magnifier (to help identify tadpoles, look at mouthparts, etc.)
- tape player (for call backs and identifying calls)
- taped recordings of anuran calls (e.g. Davidson 1996)
- compass

Survey Method:

All "suitable" habitats within an action area (area to be affected by a project) should be surveyed.

Suitable Habitat

The frog is a habitat generalist that is found in cienegas, pools, beaver ponds, livestock tanks, lakes, reservoirs, streams, and rivers at elevations of 3,281 to 8,890 feet. They are occasionally found in livestock drinkers, irrigation sloughs and acequias, wells, abandoned swimming pools, back yard ponds, and mine adits. Table E1 provides elevations at which frogs have been found by National Forest and Region in Arizona. Lower limits, below which frogs are not expected to be found, are also presented for each National Forest and Region (groups of counties). No surveys are recommended for habitats below those lower limits. However, any suitable habitat at or above those limits are potentially occupied. The limits given by Forest should guide surveys on those National Forests. If surveys are being considered outside of a National Forest, then the Regional lower limits should guide survey necessity. A similar analysis has not been conducted in New Mexico or Mexico; however, the lower limit for the Coronado National Forest can be used for Hidalgo County, New Mexico. We recommend 3,280 feet as a lower limit elsewhere in New Mexico and in Mexico.

The frog uses permanent or nearly permanent pools and ponds for breeding. Most sites that support populations of this frog will hold water year long in most years. Time from hatching to metamorphosis is shorter in warm waters than cold water, thus water permanency is probably more important at higher elevation and in the northern portion of the species' range. The species is rarely found in aquatic sites inhabited by non-native fish, American bullfrogs, or crayfish. However, in complex systems or large aquatic sites, Chiricahua leopard frog may occur with low densities of non-native predators.

Surveys in suitable lentic and lotic systems should be conducted as follows:

Lentic systems

Upon approaching a survey site, stop approximately 65 feet from the bank and search the site with binoculars. Search for frogs floating in water away from the bank as well as scanning the bank as best as possible. Walk around the entire perimeter of the site. If the entire perimeter is not surveyed, record the start and stop points as UTM coordinates. While walking along banks, use a dip net to sweep vegetation to flush frogs that do not respond to the observer's approach. After the initial perimeter survey, search mud cracks, divots, under rocks and downed branches, and any other places where frogs might find cover. If the lentic system allows, walk though the site in a zigzag fashion to further flush frogs that may be sitting on the bottom of the water. Dip net to determine the presence of amphibian larvae, fish, and aquatic insects. Record all visual

observations and audible "plops" of frogs escaping into water. Be careful not to count frogs more than once.

Table E1: Highest and lowest records for Chiricahua leopard frogs on Arizona National Forests and Regions, and recommended lower elevational limit for conducting surveys. Any suitable habitat above that lower limit could be occupied by frogs.

National Forest	Lowest Record (ft)	Highest Record (ft)	Region	Lowest Record	Highest Record	Comments	Lower Limit National Forest	Lower Limit Region
Apache-Sitgreaves NF (all but Clifton RD)	5,785	8,485	Coconino, Navajo, Apache, and Greenlee counties	4,240	8,895	Low elevation regional records all near Clifton RD	4,803	4,232
Apache-Sitgreaves NF (Clifton RD)	4,240	7,445	Coconino, Navajo, Apache, and Greenlee counties	4,240	8,895		4,240	4,232
Coconino NF	5,000	7,326	Coconino, Yavapai, and Gila counties	4,042	7,326	2 low elevation records from San Carlos Apache lands, Gila Co	4,803	4,035
Coronado	3,480	6,605	Graham, Pima, Cochise, and Santa Cruz counties	3,480	6,605		3,202	3,202
Tonto	6,000	6,405	Gila and Yavapai counties	4,040	6,405	2 low elevation records from San Carlos Apache lands, Gila Co	4,803	4,035

Lotic systems

Upon arriving at the starting point of a lotic system, record the starting point (or the most downstream point of the site) as UTM coordinates. Proceed upstream searching the banks, surrounding vegetation, and water along a minimum of 1,300 feet of a lotic system. Search under rocks, downed branches, undercut banks, and any other places where frogs might find cover as

best as possible. Where the lotic system allows, walk though the site in a zigzag fashion to further flush frogs that may be sitting on the bottom of the water. Dip net to determine the presence of amphibian larvae, fish, and aquatic insects. Record all visual observations and audible “plops” of frogs escaping into water. Be careful not to count frogs more than once.

Data collection

Data should be collected according to the Chiricahua Leopard Frog Survey Form Instructions (Attachment 3). Collect the following data at the specified locations, but note any major changes that occurred during the survey on the data form. Record the site name, UTM points, elevation, USGS quad, date, observers, and time the survey starts at the starting point of the survey. Record time the survey stops, time spent actively searching for herps, effort, any voucher specimens taken, water class, water type, search methods, water pH, relative humidity, air and water temperature, habitat characteristics (water clarity, vegetation types present, primary substrate, site width and/or length), weather conditions (wind, cloud cover, precipitation), land use, sign of potential vertebrate and invertebrate predators, as well as comments at the end point of the survey. Record any herp observations.

ATTACHMENT 2

Chiricahua Leopard Frog Survey Form

Locality Data

*SITE: | SITE AT:

For use by central data repository only:
NEW SITE: Y N | NUM: ---

*UTM ZONE: 11 12 13 | *EASTING | *NORTHING | *ELEV m ft

*QUAD: | *MIN: 7.5 15 | *YEAR: __ __ __ __ | *COUNTY: __ __---__ __ __

DIRECTIONS:

Site and Visit Conditions

*DATE: m m d d y y y y | *START TIME | *STOP TIME | *SEARCH TIME min | *OBSERVERS:

*EFFORT: Total Perimeter meters | Partial Perimeter | Left Bank | Right Bank | Both Banks

* VOUCHERS: Specimen Photo : Habitat Photo : Specimen(s) : Y N Specimen #s:

*H_2O CLASS: Lentic Lotic | *H_2O TYPE: Canal Plant outflow Riverine Wetland Stock tank Lake Reservoir Small metal/concrete tanks or drinkers

* SEARCH METHODS: Dip net Seine Trap Hand exploration Snorkel Boat Call playback | EC: | pH:

RFL HUM. | *T_{AIR}: °C F | *T_{WATER}: °C F | WATER CLARITY: Extremely clear Moderately clear Extremely heavily turbid

*LENTIC LENGTH: | *LENTIC WIDTH: m | *LOTIC WIDTH: 0-2m 3-5m 6-10m 11-20m 21-50m 51-100m

*RIPARIAN WIDTH: 0-2 m 3-5 m 6-10 m 11-20 m 21-50 >50 m | *PRIMARY SUBSTRATE (mark 1-3) : Mud/Silt Sand Gravel Cobble Boulder

*WIND: < 1 mph 1-3 mph 4-7 mph 8-12 mph 13-18 mph 19-24 mph >24 | *CLOUD COVER: 0-20% 21-40% 41-60% 61-80% 81-100%

*PRECIPITATION: None Intermittent Steady & Light Steady & Heavy Snow/Sleet | DRY SITE: Y N

VEGETATION	%	PROMINENT SPECIES
FLOATING		
SUBMERGED		
EMERGENT		
PERIMETER		
CANOPY		

*PREDATORS: (include scat and tracks)
Leeches Boatmen/Backswimmer Dragonflies
Belostomatids Beetles Warm water fish
Cold water fish Tiger salamanders Bullfrogs
Mud turtles Gartersnakes Wading birds
Blackhawk Mammals Crayfish

*OTHER ORGANISMS: | OTHER ORG. NOTES:

SITE / SURVEY NOTES:

Continued on back? Y N

Herpetofauna Observations

*SPECIES	CERTAINTY	LIFE STAGE	#	NOTES
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		
	Uncertain Certain	Egg Larvae Juvenile Adult		

ATTACHMENT 3

Site and Visit Conditions
Herpetofaunal observations

Adapted from Riparian Herp Survey Form Instructions (AGFD)

- Fields with an asterisk (*) are to be filled out for every survey, regardless of results.
- Check the site's Locality Data upon returning to the office for consistency (i.e. the site name filled out is consistent with the site name used in previous surveys).
- Upon return to the office, check each Survey Form for completeness, conciseness, and clarity prior to submitting for entry.

Locality Data:

*****SITE: A "site" is any aquatic system (or piece of an aquatic system) that is > 1 mile from any other survey locality, or if less than 1 mile apart, represents a **distinct** change in aquatic habitat types (e.g., riverine vs. lake or cienega). Features with unique names are considered unique sites regardless of how far apart they are. Record the site name as it is marked on the United States Geologic Survey (USGS) quadrangle (hereafter quadrangle or quad). If the site is unnamed on the quad, refer to the corresponding land management map (e.g., U.S. Forest Service map, BLM Surface Management Responsibility map). If the site doesn't have a name, write "unnamed" preceding the feature; similarly, if the site is not marked on any map, write "unmarked" preceding the feature (e.g., Unnamed Wash, Unmarked Tank).

SITE AT: This field should always be filled out for unnamed and unmarked sites and for large/long aquatic systems. For other localities, use this field *as needed* to enhance a site name (i.e., to verbally pin-point a site in space). Use such features as the nearest road crossing (e.g., East Verde River at **Highway 87**) stream confluence (e.g., East Fork Gila River at **Diamond Creek**) or topographic feature (e.g., San Francisco River, W of Glenwood) in the description.

NEW SITE: This field is used for central database management purposes only and is not to be filled out by survey personnel.

NUM: This field is used for central database management purposes only and is not to be filled out by survey personnel. A site number is a unique number that, once assigned to a site, will always be used in conjunction with that site. The site number starts with a 3-letter code that describes the land manager. These 3 letters are followed by a hyphen and then a 4-digit number (e.g., TON-0001, COC-0153).

*UTM ZONE: Circle "11", "12" or "13" to note whether the **starting point** of the survey is in UTM grid zone 11 (west of 114 degrees longitude) or 12 (east of 114 degrees longitude). Most of Arizona except for the extreme western portion of the state is Zone 12. Most of New Mexico, except for the extreme western portion is in Zone 13.

*****EASTING: Record the **starting point** of the survey as a 6-digit number. An example of a UTM x-coordinate is 295440E. Use a Global Positioning System (GPS) unit to measure the UTM coordinate. The UTM coordinate should be measured in North American Datum 1927 (NAD27Conus for Garmin units). Check that the GPS unit is reading the appropriate Zone (most of AZ is Zone 12, most of NM is Zone 13). Alternatively, read

UTM coordinate. The UTM coordinate should be measured in North American Datum 1927 (NAD27Conus for Garmin units). Check that the GPS unit is reading the appropriate Zone (most of AZ is Zone 12, most of NM is Zone 13). Alternatively, read the UTM coordinate from the quad. The first 3 numbers will be found on the top or bottom edge of the quad. These numbers are in 100,000-meter increments. The fourth number describes a point with 100-meters accuracy. The fifth number describes a point with 10-meters accuracy. The last number will be a zero. Use a coordinate scale to determine the fourth and fifth numbers.

*NORTHING: Record the **starting point** of the survey as a 7-digit number. An example of a UTM y-coordinate is 4318410N. Use a Global Positioning System (GPS) unit to measure the UTM coordinate. The UTM coordinate should be measured in North American Datum 1927 (NAD27). Check that the GPS unit is reading the appropriate Zone (most of AZ is Zone 12, most of NM is Zone 13). Alternatively, read the UTM coordinate from the quad. The first 4 numbers will be found along the left or right edge of the quad. These numbers are in 1,000,000-meter increments that tell you how far north of the equator you are. The fifth number describes a point with 100-meter accuracy. The sixth number describes a point with 10-meter accuracy. The last number will be a zero. Use a coordinate scale to determine the fifth and sixth numbers.

*****ELEV: Record the elevation at which the **starting point** of the survey occurs. Read the elevation off of the survey quad or GPS unit. Be sure to indicate the measurement units (ft or m). The contour interval and unit (meters or feet) is written in the center of the bottom margin of the quadrangle. To convert meters to feet multiply by 3.281. To convert feet to meters multiply by 0.3048. If using a GPS unit, ensure you have adequate satellite coverage for an accurate elevation reading (at least 4 satellites).

*****QUAD: Record the quadrangle name as it appears on the quadrangle. The name of the quadrangle appears in the upper and lower right hand corners of the quadrangle. If more than one quad is used in the survey, record the name of the quad in which the survey starts and note the name(s) of the other quad(s) in the DIRECTIONS.

*****MIN: Circle "7.5" or "15" to note whether the quadrangle series is 7.5 or 15 minutes. The series of the quadrangle can be found in the upper right hand corner of the quadrangle.

*****YEAR: Record the year of the quadrangle as it is printed in the lower right corner of the quadrangle. If more than one year appears on the map, record the year of the most recent revision.

*****COUNTY: Record the state abbreviation (e.g., AZ, NM) followed by a hyphen and then the first 4 letters of the county (e.g., AZ-MARI, AZ-YAVA, NM-CATR, NM-SIER). The county name can be found in the upper right corner of the quadrangle if the quad covers an area within a single county. For quads that cover areas in two or more counties, the names of the counties will appear somewhere in the topographic region of the quad. National forest maps, road maps, and gazetteers are also useful in identifying counties.

DIRECTIONS: Write the directions to the site. **Keep them short and pertinent** (e.g., on FS 105 ~ 4.3 MI N of FS 105/FS 393 jct.). Directions are especially important when there are no roads or when existing roads are not marked on your maps. Use the directions N, NE, E, SE, S, SW, W, and NW instead of "turn right" or "veer left". This field can also contain any information or comments you want to convey to other field personnel. For example: "Contact landowner for permission to access (602) 555-9683"; "Also survey adjacent tank and draw"; etc.

Site and Visit Conditions:

*****DATE: Record the date of the survey as eight numbers giving the month first, followed by the day then the year (e.g., 10-27-1993, 06-02-1994).

*****START TIME: Record the time the surveyor begins searching for herps using a 24-hour clock.

*****STOP TIME: Record the time the surveyor stops searching for herps using a 24-hour clock.

*SEARCH TIME: Record the time spent actively searching for herps in minutes. The time recorded should include only time spent actively searching for herps and should not include time taken to write field notes, complete data sheets, read data sheet instructions, or other activities that may be performed while at the site.

*****OBSERVERS: List the names of all people present during the survey. Record the names as: first initial, period, second initial, period, space, and full last name (e.g., M.J. Sredl, C.W. Painter).

*****EFFORT: There are 5 categories of effort:

TP = Total Perimeter
PP = Partial Perimeter
LB = Left Bank
RB = Right Bank
BB = Both Banks

Circle all category(s) that apply. For all categories other than TP, record the distance surveyed in meters. The minimum acceptable survey distance for linear systems and large lentic systems (> 20 acres) is 400m (0.25 mile). Use category BB for any lotic system in which it is possible for you to access both banks (i.e., to meander from shore to shore). Use categories LB and RB for large, deep, and/or swiftly flowing lotic systems in which you are unable to meander shore to shore. LB and RB should always be filled out together even if you didn't survey, or were unable to access, one of the shores (e.g., LB = 0000m, RB = 0350m; RB = 0050m, LB = 0200m). Left and right banks are in reference to a person looking upstream. To calculate meters walked use a map wheel, range finder, or measuring tape. If using a map wheel to determine the distance in kilometers (or miles), be sure to use the scale on the map wheel that corresponds to the scale of your map or quad. Multiply your result by 1000 to get meters. Round the final result to the nearest 25-meter value. Alternatively, multiply the value generated from the map wheel in miles by 5,280 feet/mile. Multiply this new value by 0.3048 meters/foot. Remember, during the course of any survey, the surveyor should dip net, comb through bushes and grasses, turn over rocks, and scan the water and shore for herpetofauna.

*****VOUCHERS: Note how many photo vouchers of specimens were taken at a site. Write the number as 2 digits (e.g., 00 or 13). Photo vouchers of specimens should be close-ups (i.e., macro shots) of diagnostic characters (e.g., thigh pattern and dorsolateral folds of leopard frogs, scale row of lateral stripes in gartersnakes, dorsal and cranial views of Arizona toads). Note how many habitat photographs were taken at a site. Write the number as 2 digits (e.g., 00 or 02). Habitat photos should be taken at any site in which target riparian herps were found, at any historical locality regardless of results, and at any survey site that has suitable habitat even if no target riparian herps were found. Keep a detailed log of all photos taken with the camera. Circle "Y" (yes) or "N" (no) as an indication of whether voucher specimens were collected at a site. If "Y" is circled,

the collection tag number(s) should be written in the Specimen #s field. In New Mexico, all specimens collected should be given to the New Mexico Dept. of Game and Fish, Endangered Species Program for identification and deposition in the Museum of SW Biology at Univ. of New Mexico. In Arizona, give specimens to the Arizona Game and Fish Dept., Nongame Branch in Phoenix for identification and deposition in the Arizona State University Museum.

*****H_2O CLASS: Circle 1 category that best describes the hydrological class of the water system you have surveyed.

Lentic = still water (e.g. pond)
Lotic = flowing water (e.g. stream)

*****H_2O TYPE: Circle 1 category that best describes the type of water you have surveyed. The categories are based upon lotic/lentic characteristics as well as the size/magnitude of the water body:

Canal = manmade (metal, concrete or earthen) diversion of riverine water
Plant outflow = sewage and electric plants; any chemical or mechanical processing of water; storm drainages
Riverine = natural flow, from raging rivers to streams to seeps
Wetland = an inland body of water that is primarily emergent vegetation (e.g., cienega)
Stock tank = an earthen-dammed or dredged basin that catches run-off for livestock or wildlife
Lake = an inland body of water that is primarily open water
Reservoir = a dammed riverine system that is primarily used for recreation and/or human water supply
Small metal/concrete tanks and drinkers = manmade water holding structures

*SEARCH METHODS: Circle all methods used to search for herps. If needed, include a description of other techniques used to search in the SITE / SURVEY NOTES with a footnote reference. Remember, during the course of any survey, the surveyor should dip net, comb through bushes and grasses, turn over rocks, and scan the water and shore for herpetofauna.

EC: Use an electroconductivity meter to measure. The water sample should be taken 1 centimeter below waters' surface and 1 meter from shore. For bodies of water less than 2 meters wide, take the sample from the center. Record value as µS (micro-Seimens). Be sure to: 1) take the cap off the meter before using, 2) keep the level of the water sample below the mark on the meter, 3) turn the meter on before measuring the conductivity of the sample, and 4) turn the meter off when finished sampling. Meters should be calibrated monthly.

pH: Measure pH using a pH meter. The water sample should be taken from water column 1 meter from shore. For bodies of water less than 2 meters wide, take the sample from the center. Be sure to: 1) take the cap off the meter before using, 2) keep the level of the water sample below the mark on the meter, 3) turn the meter on before measuring the pH of the sample, and 4) turn the meter off when finished sampling. Meters should be kept hydrated and calibrated monthly.

REL. HUM.: With a sling psychrometer or hygrometer, measure relative humidity 1.5 meters above ground and 1.5 meters from water. Record as percent.

*T_{AIR}: Measure air temperature to the nearest 10th of a degree (degrees Celsius preferred, circle C or F) 1.5 meters above ground and 1.5 meters from the water. Be sure thermometer is shaded and completely dry.

*T_{WATER}: Measure water temperature to the nearest degree (degrees Celsius preferred, circle C or F) 1 centimeter below water's surface and 1 meter from shore. For bodies of water less than 2 meters wide, measure temperature at the center. Be sure to shade the thermometer.

WATER CLARITY: Circle 1 phrase that best describes the survey area.

*LENTIC LENGTH: For lentic systems, record the length (i.e., longest axis) of the system in meters. Measure the entire system (not just the portion surveyed), and use the standing water at the time of the survey as your boundaries. Do not measure the normal waterline or highwater mark. For large systems, estimate the length using a map. Do not rely on a visual estimate for large systems.

*LENTIC WIDTH: For lentic systems, record the width (i.e., shortest axis) of the system in meters. The width should be the maximum distance perpendicular to the length axis. As with the length, the width should reference the entire lentic system, not just the portion surveyed, and should be determined based upon the standing water present at the time of the survey, not the usual waterline or high water mark. Use a map as a guide for larger systems.

*LOTIC WIDTH: For lotic systems, select one range that best describes the width of water at the time of the survey. Do not measure the normal waterline or the high water mark.

*RIPARIAN WIDTH: Circle the category that includes the maximum width of the riparian area in meters. Riparian width should be measured from the boundary of riparian vegetation and upland vegetation. For a lentic system, include the area of riparian vegetation along the shore of the body of water and any vegetated waters. For a small lotic system in which both banks can be surveyed simultaneously, include the zone of riparian vegetation on both banks of the body of water surveyed and any vegetated waters. For large or swiftly flowing lotic systems, include only bank that was surveyed or the maximum width of riparian vegetation on both banks. Riparian width is measured for the area surveyed.

*PRIMARY SUBSTRATE: Circle from 1 to 3 categories as appropriate. All substrate types may be present, but choose only those that best describe the area potentially inhabited by target species.

Mud/Silt = 0.001-0.1 mm
Sand = 0.1-2 mm
Gravel = 2-32 mm
Cobble = 32-256 mm
Boulder >256 mm
Bedrock = exposed sheet of rock

*WIND: Circle 1 category as appropriate. Wind should be measured 1.5 meters above the ground and 1.5 meters from the water. If using a wind meter, be sure to: 1) hold meter near the top so that you are not blocking any holes, 2) face into the direction of the wind while reading the meter, and 3) use the left scale for wind strengths < 10 mph, and use the right scale (by putting your index finger over the red knob on top of the meter) for wind strengths ≥10 mph. Wind categories are those used in the Beaufort scale:

≤1 mph = smoke rises vertically
1-3 mph = wind direction shown by smoke drift
4-7 mph = wind felt on face, leaves rustle
8-12 mph = leaves and small twigs in constant motion, wind extends light flag
13-18 mph = raises dust and loose paper, small branches are moved
19-24 mph = small trees begin to sway, crested wavelets form on inland waters
>24 mph = greater effect than above

*CLOUD COVER: Circle 1 category as appropriate. Categories are based on percent cover.

*PRECIPITATION: Circle 1 category as appropriate.

*DRY SITE: Circle Y (yes), if the site has no standing or flowing water on the surface. Circle N (no) water is present.

VEGETATION & PROMINENT SPECIES: Record the percent of the area potentially inhabited by target species that is covered by floating vegetation (e.g., broad-leafed macrophytes and dense algal mats), submerged vegetation, emergent vegetation (e.g., cattails, sedges, rushes), perimeter vegetation (i.e., up to 1 m from waters edge), and canopy vegetation. Use increments of 5 percent (i.e., 1percent effectively = 0). Record the genus name or common name (only if positively identified) of the 1-4 most prominent species that best describe the surveyed area.

*****PREDATORS: Circle all predators seen or otherwise detected at a survey site. Most predator categories lump together similar organisms and/or organisms with similar effects on riparian herps. Record amphibians and reptiles that are predators on other herpetofauna in the Herpetofauna Observations table. For **crayfish**, include claws and carapaces as evidence of presence. For **dragonflies**, do not include damselflies. For **beetles**, include any large aquatic beetles observed, such as hydrophilids and dytiscids. **Warm water fish** include bass, carp, catfish, perch, sunfish, and walleye. **Cold water fish** include trout and pike. **Large wading birds** include American bittern, black-crowned night heron, egrets, great blue heron, and green-backed night heron. **Mammals** include only medium-sized mammals such as skunk, ring-tail, and raccoon.

*****OTHER ORGANISMS: This field is to be used for observations of species other than riparian herpetofauna. Riparian herps are to be recorded in the "Herpetofauna Observations" table. List all non-riparian herps by 4-letter genus/species code following the list derived from Stebbins (2003) or common name. List federal or state sensitive species of other organismal groups or any other species whose occurrence merits noting by common name. Use the OTHER ORG. NOTES field as needed to expand upon why you listed a species.

OTHER ORG. NOTES: Use this field to write out noteworthy observations about any or all of the species listed in OTHER ORGANISMS (e.g., side-blotched lizard observed mating, great horned owl roost site observed, area heavily impacted by elk grazing).

SITE / SURVEY NOTES: Use this field to describe the most outstanding features of a survey or site. **Don't be redundant** with fields already completed. Write short, specific comments that emphasize habitat quality and why you think you did or did not find herps. Be sure to comment on any land use in, around, or in proximity of the survey area that may potentially impact the study site (e.g., large mining operation 0.5 mile upstream of survey site, agricultural spraying 1 mile from survey site). You can also use this field to describe any noteworthy similarities or dissimilarities between the area searched and the total area (e.g., wash devoid of vegetation except in area of survey, survey covered the north end of the lake which was the only area with emergent vegetation).

Herpetofauna Observations:

*SPECIES: Record all riparian herp species (target or non-target) detected during a survey in this column. Record non-riparian herpetofauna in the OTHER ORGANISMS and OTHER ORG. NOTES. If no species are observed, record “NONE.” Use the unique 4-letter Genus-species code (Derived from Stebbins (1985)") for all riparian herp species. When an organism cannot be identified to species (e.g., "I saw a ranid-like frog", or "I saw an anuran egg mass"), use the 4-letter code corresponding to the taxonomic classification for which you are confident in your identification. For the examples above, the ranid-like frog would be assigned the code "RANA", and the egg mass would be coded as "ANUR". If you are confident you saw a leopard frog but are not certain which species you saw, use the code "RAPC." Do not use historic information to bias your decision on species identification. Record your most confident observation and justify it in the NOTES or COMMENTS.

CERTAINTY: Circle 1 word to indicate your level of certainty about your identification of each species. Certainty of identification should be based on species-specific diagnostic characters (e.g., thigh pattern and dorsolateral folds in leopard frogs, scale row of lateral stripes in gartersnakes, lack of dorsal stripe and cranial crests in Arizona toads). For information on diagnostic characters of species, see the references listed in the Survey Protocol or other appropriate diagnostic keys.

LIFE STAGE: Circle the life stage of each species observed. Use separate rows for different life stages of the same species. A juvenile leopard frog is usually < 55 mm SVL, while an adult is > 55 mm SVL or exhibits obvious sign of breeding condition (e.g., swollen thumbpads, stretched vocal sacs)

OBSERVED: Enter the number of individuals of each species and life stage you encountered. Do not estimate total numbers within the survey area, but record only the number that you saw. For egg masses, record the number of egg masses, note the overall size of mass, condition, and stage of embryos in the NOTES or COMMENTS sections

NOTES: Record any relevant notes specific to the species or life stage observed. Types of observations to include are as follows: 1) what criteria were used to identify a species; 2) if species identification is uncertain, what was observed including both physical features and behaviors would be of use (e.g., “dorsal spots obs.,” “ranid like plop,” “no bullfrog peep”); 3) note the presence of disease or deformities.

APPENDIX F

Protocols for Transportation, Captive Care, and Release of Leopard Frogs (*Rana* spp.)

General Guidelines for Transportation of Leopard Frog Life Stages

- Transportation
  - General Container Information
    - Use only plastic containers, no metal or glass.
    - Containers should be water tight when tipped upside down.
    - Do not use bags more than once. Use only new, rinsed bags.
    - Carry 1 or 2 extra containers filled with water in case of an emergency (i.e. leak).
  - Type of Containers per animal size
    - Larvae at any stage, ship well in 11" x 10.5" (1 gallon self closing bags (e.g. Ziplocs®) or in aquarium grade plastic bags sealed with a rubber band. Aquarium grade bags can be inflated and sealed with rubber bands to prevent collapsing. Double bagging should be considered for trips longer than 4 hours or when driving on rough roads.
    - Larvae may also be transported in hard plastic buckets or containers that have tight fitting lids.
    - GladWare® is highly recommended for transportation of metamorphs, juveniles, and adults. They keep them from being crushed and they are reusable.
  - Preparing Containers
    - Thoroughly rinse all shipping containers with water. Do not use any type of detergent or soap to clean the containers.
    - The GladWare® also needs holes drilled in the top. A standard hole punch works well, approximately 16 holes. Drill from the inside out so that no sharp edges protrude into the animal holding space.
    - If desired, mark each bag with identification of eventual destination and the number of animals in the container.
  - Stocking densities
    - Per gallon bag for short shipments.
      - Eggs: 1 mass per bag, minimize disturbance and division of mass
      - Larvae under ½": 25 per bag
      - Larvae 1" - 1 ½": 15 per bag
      - Larvae over 1 ½": 10 per bag
      - Recently metamorphosed frogs: 5 per container or bag
    - Avoid overcrowding
  - Water
    - Water put in the bags must be chlorine and chloramine free. Dechlorinating chemicals can be used to immediately remove chlorine.
    - Stream or pond water from which the animals originated can be used. Avoid capturing aquatic invertebrates or organic debris.

        - Other alternatives are bottled drinking water or tap water left uncovered for 24 or more hours.
        - For larvae, fill bags by approximately 75 percent or greater volume water to avoid excessive sloshing.
        - For metamorphs, juveniles, or adults place 20 ml of water with a leaf of romaine or iceberg lettuce for hiding. If transporting from the wild, use algae or leaves instead.
        - Shipping
            - Blow out bags with a breath or an oxygen cylinder to prevent collapse during shipping. Allow a little space within the bag to allow for expansion with elevation changes.
            - Foam or plastic insulated ice chests work well for protecting bags from temperature extremes and accidental damage. Foam boxes that fit within a cardboard box are commercially available from tropical fish dealers.
            - Use towels, newspapers or bags blown full of air to fill in empty spaces between bags in the shipping container.
            - Battery operated air pumps are useful in aerating buckets of animals during transport.
    - Temperature
        - Optimal shipping temperature is a compromise between the captive and anticipated release temperature.
        - To keep animals cool in warm weather, place a 1-3 inch layer of cubed ice inside plastic bags on the bottom of an insulated ice chest. Cover the ice with a layer of plastic, then a few layers of towels, newspaper, or cardboard to insulate the animals from the direct cold. It is suggested to place a piece of foam between ice and animals, so if ice melts the animals will float instead of settling in the water.
        - A thermometer with a remote sensor inside the container can assist in monitoring the temperature while shipping.
        - Alternatively, animals could be moved in open containers if kept inside air-conditioned vehicles capable of maintaining the appropriate desired temperature.
        - When tadpoles arrive at the rearing facility, it is important to equalize the temperature of the shipping container and that of the tank into which the animals will be released. This is easily achieved by floating the plastic bag or container in the tank for 15-20 minutes. An aquarium thermometer can be used to ensure that the two containers are within one or two degrees of each other before transferring the animals.

<u>Leopard Frog Egg Mass Collection and Transportation Protocol</u>

- Make sure that all field equipment (boots, nets, truck tires, etc.) that may have been used at other locations have been disinfected to prevent spread of chytrid fungus. Various methods have been shown effective: 1) rinsing with 1 percent sodium hypochlorite (household bleach); 2) 20-second exposure to 70 percent ethanol or 1 mg/ml

benzalkonium chloride; 3) desiccation and exposure to 50-60°C heat for 30 minutes; and, 4) either 0.012 percent Path-X™ or 0.008 percent quaternary ammonium compound 128 (both containing DDAC, didecyl dimethyl ammonium chloride as active ingredient). Johnson, ML, L Berger, L Philips and R, Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 57:255-260.

- If possible, record the water and air temperature at the site, location of the egg mass in the pond or creek, and current and recent weather events. Additional water quality data may be collected at this time as resources and circumstances permit (pH, dissolved oxygen, ammonia, nitrite, nitrate, total hardness, calcium hardness, alkalinity, chlorine, copper, iron). Forward this information with the egg mass and to a member of the Chiricahua leopard frog Recovery Team.

- Egg masses should be freshly laid (< 5 days) or show little sign of development. Reduced hatched rate and mortality of tadpoles increases greatly once the embryonic tadpoles are developed to the point they are able to wriggle within their eggs.

- Use a new, 1 gallon, self-closing plastic bag to transport the egg mass. Rinse the bag with the source water thoroughly before use and write the name of the collection site on the bag. Place only 1 egg mass per bag (approximately 500 eggs or fewer). If the egg mass is larger, divide into smaller portions of approximately 300-500 eggs each.
    - To transfer the egg mass into the bag, submerge the bag and fill with clear water. Next, carefully cut away any vegetation or sticks attached to the egg mass, without dividing the egg mass. In your cupped hand(s), gently move the egg mass into the submerged, opened, plastic bag. Be careful not to transfer aquatic invertebrates, mud, leaves, and other organic debris into the bag.
    - If only a portion is being collected, use 2 plastic spoons and your fingers to separate the egg mass. Place 1 hand underneath the egg mass, to prevent the eggs from touching the substrate or breaking apart. Take caution not to remove the portion of the egg mass attached to the supporting vegetation or debris.
    - Once the egg mass is in the bag, bring it to the surface and seal the bag. Allow approximately ½ - 1” of air space. Once sealed, placed the filled bag into a second bag in case of leakage.
    - If the situation permits, collect an additional 2 – 5 gallons of water from the site in clean plastic bags or plastic buckets. This source water may be important for initial acclimation of egg mass in the captive environment.
    -

- Transport the egg mass in the plastic bag within a styrofoam or hard plastic cooler to provide a stable appropriate thermal environment. The bag should be supported within the cooler to prevent leakage through the seam and excess sloshing during transport. Towels, newspaper, or air filled bags work well in supporting the egg mass bag in the cooler. Ice or freezer packs may be added to the cooler to maintain a suitable temperature (60-75 degrees F.), provided the frozen material does not directly contact the egg mass bag.

- Coordinate with the captive rearing facility prior to departure to alert them to your estimated time of arrival and minimize transit time.

Leopard Frog Tadpole Collection and Transportation Protocol

- Make sure that all field equipment (boots, nets, truck tires, etc.) that may have been used at other locations have been disinfected to prevent spread of chytrid fungus. Various methods have been shown effective: 1) rinsing with 1percent sodium hypochlorite (household bleach); 2) 20-second exposure to 70 percent ethanol or 1 mg/ml benzalkonium chloride; 3) desiccation and exposure to 50-60°C heat for 30 minutes; and, either 0.012 percent Path-X™ or 0.008 percent quaternary ammonium compound 128 (both containing DDAC, didecyl dimethyl ammonium chloride as active ingredient). Johnson, ML, L Berger, L Philips and R, Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 57:255-260.

- If possible, record the water and air temperature at the site, location of the tadpoles in the pond or creek, and current and recent weather events. Additional water quality data may be collected at this time as resources and circumstances permit (pH, dissolved oxygen, ammonia, nitrite, nitrate, total hardness, calcium hardness, alkalinity, chlorine, copper, iron). Forward this information with the tadpoles and to a member of the Chiricahua leopard frog Recovery Team.

- Tadpoles to be collected should be moving independently and have already absorbed their yolk. Recently hatched tadpoles that rest and only move when stimulated have higher mortality during transportation and acclimation to captivity than older more active tadpoles.

- Use a new, one gallon, self-closing plastic bag to transport the tadpoles. Rinse the bag with the source water thoroughly before use and write the name of the collection site on the bag.
    - Use a soft nylon net to collect the tadpoles to minimize damage to their skin. A clear plastic bag may be used instead of a net in some circumstances and causes even less damage to the tadpoles.
        - If the tadpoles are small (< 1 inch Snout-Tail Length), place no more than 25 tadpoles per bag.
        - If the tadpoles are large (> 1 inch Snout-Tail Length), place no more than 15 tadpoles per bag.
    - Fill the 1 gallon transport bag with clear water.
        - If you are using a nylon net to collect tadpoles: once you have netted the tadpoles, quickly lift them out of the water and place the entire net below the waterline in the transport bag. Gently swish the net back and forth to release the tadpoles into the transport bag.
        - If you are using a plastic bag to collect tadpoles: let the bag drift open underwater as you swoop it toward the tadpoles. Lift the bag above the water surface and seal the bag with just a slight gap so that excess water

can be squeezed out. Transfer the tadpoles and the small amount of water into the 1 gallon transport bag.
        - Avoid placing aquatic invertebrates, mud, leaves and other organic debris into the transport bag.
    - Close the transport bag and allow approximately 1" of air space. Once sealed, placed the filled bag inside a second bag in case of leakage.
    - If the situation permits, collect an additional 2 – 5 gallons of water from the site in clean plastic bags or plastic buckets. This source water may be important for initial acclimation of tadpoles in the captive environment.

- Transport the tadpoles in the plastic bag within a styrofoam or hard plastic cooler to provide a stable appropriate thermal environment. The bag should be supported within the cooler to prevent leakage through the seam and excess sloshing during transport. Towels, newspaper, or air filled bags work well in supporting the tadpole bag in the cooler. Ice or freezer packs may be added to the cooler to maintain a suitable temperature (60-75 degrees F.), provided the frozen material does not directly contact the tadpole bag.

- Coordinate with the captive rearing facility prior to departure to alert them to your estimated time of arrival and minimize transit time.
    - If the water quality of the source water and the captive rearing enclosure are radically different with respect to pH and hardness, effort should be made to adjust the enclosure water prior to introduction of tadpoles. In any case, the tadpoles should be floated in their bags in the water of enclosure to allow for them to reach equilibrium with the enclosure water temperature before release. If the pH and hardness cannot be adjusted, add small amounts of enclosure water to the bags to gradually acclimate the tadpoles. You may want to add the extra source water to the enclosure to try and ameliorate the effects of the different water quality parameters.

<u>Juvenile and Adult Leopard Frog Collection and Transportation Protocol</u>

- Make sure that all field equipment (boots, nets, truck tires, etc.) that may have been used at other locations have been disinfected to prevent spread of chytrid fungus. Various methods have been shown effective: 1) rinsing with 1 percent sodium hypochlorite (household bleach); 2) 20-second exposure to 70 percent ethanol or 1 mg/ml benzalkonium chloride; 3) desiccation and exposure to 50-60°C heat for 30 minutes; and, either 0.012 percent Path-X™ or 0.008 percent quaternary ammonium compound 128 (both containing DDAC, didecyl dimethyl ammonium chloride as active ingredient). Johnson, ML, L Berger, L Philips and R, Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 57:255-260.

- If possible, record the water and air temperature at the site, location of the frog in the pond or creek, and current and recent weather events. Additional water quality data may be collected at this time as resources and circumstances permit (pH, dissolved oxygen, ammonia, nitrite, nitrate, total hardness, calcium hardness, alkalinity, chlorine, copper,

iron). Forward this information with the tadpoles and to a member of the Chiricahua leopard frog Recovery Team.

- Frogs may be transported in a new, 1 gallon, self-closing plastic bag. No more than 5 juveniles (Snout-Vent Length < 2 inches) should be placed per bag. Larger frogs (Snout-Vent Length ≥ 2 inches) should be transported with no more than 1 frog per bag. Hard plastic containers may be used depending on the circumstances (e.g., disposable Gladware™, Rubbermaid© containers, 5 gallon buckets with lids, etc.). Hard containers should have ventilation holes on the lid—make sure the ventilation holes have no rough edges projecting inward that could harm the frogs. The containers should be rinsed with the source water thoroughly before use and approximately ½" to 1"deep water added. Write the name of the collection site on the container.
    - Many frogs benefit from soft plant material added to the water. This can be aquatic vegetation, sphagnum moss, or shredded deciduous leaves. This material provides underwater perch sites that helps calm down some frogs. It also provides some padding if the container is jostled during transport. Be wary of putting too much material in the container as this can trap and drown frogs.
    - If the situation permits, collect an additional 2 – 5 gallons of water from the site in clean plastic bags or plastic buckets. This source water may be important for initial acclimation of smaller frogs in the captive environment.

- Transport frogs in a plastic bag by placing them within a styrofoam or hard plastic cooler to provide a stable appropriate thermal environment. The bag should be supported within the cooler to prevent leakage through the seam and excess sloshing during transport. Towels, newspaper, or air filled bags work well in supporting the frog bag in the cooler. Ice or freezer packs may be added to the cooler to maintain a suitable temperature (60-75 degrees F.), provided the frozen material does not directly contact the tadpole bag.
    - If the containers are too large to be managed this way, care should be taken to limit the speed of temperature change during transport. Newspaper or insulation can be duct-taped around the container and ice-packs slipped between the bucket and the insulation material.

- Coordinate with the captive rearing facility prior to departure to alert them to your estimated time of arrival and minimize transit time.
    - For frogs with a known history of mortality following transport, initial efforts at the captive rearing facility may include some anti-shock measures. This may include supplemental oxygen bubbled through the water, addition of no more than 4.5 g of salt or sea salt to liter of water in the enclosure (which should be completely rinsed and refilled with freshwater 48 hr after arrival to removal all supplemental salts), and addition of artificial slime products used for stressed tropical fish. Initial treatment with itraconazole baths (1 percent solution dissolved to 0.01 percent strength in a 0.6 percent salt solution as a 5 minute soak) is warranted if the frogs come from an area known to be contaminated with chytridiomycosis or if there have been recently mortalities in the population.
    - If the water quality of the source water and the captive rearing enclosure are radically different with respect to pH and hardness, effort should be made to

adjust the enclosure water prior to introduction of frogs. In any case, the frogs should be floated in their bags in the water of enclosure to allow for them to reach equilibrium with the enclosure water temperature before release. If the pH and hardness cannot be adjusted, add small amounts of enclosure water to the bags to gradually acclimate the frogs. You may want to add the extra source water to the enclosure to try and ameliorate the effects of the different water quality parameters.

Arizona Leopard Frog Captive Care Protocol

- Minimization of disease transfer
  - Make sure that all enclosure materials that may have housed other amphibians have been disinfected to prevent spread of chytrid fungus. Various methods have been shown effective: 1) rinsing with 1 percent sodium hypochlorite (household bleach); 2) 20-second exposure to 70 percent ethanol or 1 mg/ml benzalkonium chloride; 3) desiccation and exposure to 50-60°C heat for 30 minutes; and, either 0.012 percent Path-X™ or 0.008 percent quaternary ammonium compound 128 (both containing DDAC, didecyl dimethyl ammonium chloride as active ingredient). Johnson, ML, L Berger, L Philips and R, Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 57:255-260.

- Preparation time
  - Enclosures should be functioning at least 14 days ahead of amphibian arrival to ensure that the systems are maintaining stable water quality parameters and to allow initial colonization of filter media with organisms crucial to each stage of the nitrogen cycle (i.e., capable of converting ammonia to nitrite and nitrite to nitrate).

- Enclosures
  - As large an enclosure should be used as possible to provide maximum water capacity. A large water volume with proper filtration maintains more stable water quality parameters than a smaller water volume similarly equipped.
  - All should be constructed of easily disinfected materials like plastic, glass, or fiberglass.
    - Containers of cement-based products are one alternative, provided they are well aged and no longer leaching alkaline. Unsealed concrete can be problematic to disinfect between groups of animals. Rough concrete surfaces have been linked to mycobacterial infections in aquatic frogs, an incurable fatal infection.
    - No metal containers, galvanized or not. These may leach metal ions that are known toxicants to amphibians.
    - Aquaria, plastic kiddy pools, plastic cattle troughs, and aquaculture tubs work well. The specific enclosure depends on the husbandry plan to be implemented. In most cases, as large an enclosure as possible should be

chosen so that the filtration system is as complete as possible (i.e., mechanical, chemical, biological, UV irradiation) to achieve and maintain stable water quality within appropriate parameters.
    - PVC or plastic pond liners are also acceptable, provided they are labeled as “fish safe” by the manufacturer.
    - Water depth should be at least 5 inches for swimming larvae and no more than 5 inches for metamorphosing larvae and froglets.
- Lids
    - All containers should have screened or solid lids to prevent larvae, metamorphs or adults from jumping out or escaping. The screens should be plastic rather than metal to avoid oxidized metal falling into the enclosure.
        - An alternative is to use taller containers and keep the water level low.
- Cage furniture
    - Hiding spots, basking spots and aquatic perches are essential for frogs to feel comfortable in their enclosures. Visual barriers are important to reduce stress between frogs within the same enclosure and to reduce stress caused by activity outside the enclosure.
    - Disturbance should be minimized by setting up the holding containers in low (human) activity areas.
    - Artificial floating plants provide larvae with resting and hiding places.
    - Live plants or algae may be used if obtained from the same location as the animals, or if the plants are thoroughly rinsed and stored in tap water for 30 days. More stringent disinfection measures may be appropriate depending on the level of quarantine desired for the population of frogs. Copper sulfate, levamisole and chlorhexidine baths may be used to eliminate protozoa, helminthes and other pathogens that may find refuge in the plants. Chytrid fungus may survive on aquatic plants but may be eliminated by soaking the plants in water maintained at 99°F for at least 18 hours.
    - Plastic window screen mesh can be used as rafts and feeding platforms. Tadpoles often prefer resting above the bottom of the water column.
    - PVC pipe and fixtures can be used as underwater refuges
    - The underwater perches should be stratified so that an animal can seek refuge at a comfortable depth of water. Some of the perches should be placed beneath overhead basking lights.
- Lighting
    - Where practical, access to natural sunlight at levels approximately equal to the wild habitat is beneficial.
    - Artificial lighting can be provided using fluorescent lights.
    - Ultraviolet B may be provided using specific fluorescent bulbs. The need for this is uncertain at present.
    - Multiple basking sites should be provided on the land and on underwater perches using incandescent lights or ceramic bulb heaters.

        - Light should be provided in a patchwork mosaic so an animal can choose between light and dark spaces.
    - Temperature
        - Water temperature should be maintained between 68°F and 80°F.
            - Basking lights may be suspended over underwater rocks to provide thermal variation that offers larvae the chance to thermoregulate.
        - Larval growth rates are directly correlated with environmental temperatures. Within the biologically appropriate temperature ranges, higher temperatures typically yield faster growth rates.
        - Temperatures above 72°F are recommended to reduce the risk of the fungal disease saprolegniasis.
    - Inserts for rapid movement of animals
        - Holding containers can be fitted with mesh bottom inserts that contain the larvae or adults when the inserts are removed from the water. This insert is then placed into a clean container of the same size. This is not practical for complex systems but is often useful for small enclosures maintained on a sponge filter.

- Stage specific considerations
    - Housing-Embryos
        - In general, the enclosure should be large enough so that the pump produces minimal current to agitate the egg mass or recently hatched larvae.
        - Gently aerate water in embryo holding tank with a sponge filter and aquarium pump or an aquarium power head. If a sponge filter is not available, an airstone may be used. A sponge filter is preferred as it provides biological filtration if it has been properly aged. An airstone does not provide any filtration.
        - Egg masses and recently hatched larvae should be suspended off the bottom of the holding container. Plastic window screen mesh or rinsed cheese cloth material are useful for building a “hammock” underneath the eggs to suspend them in the water.
        - Remove dead hatchlings or eggs covered with fungus from the mass if possible with minimal disturbance. Ammonia levels can quickly rise to toxic level from decomposing eggs or hatchlings even with biological filtration.
        - Stocking density: 1 egg mass (up to 1000 eggs) per 10 gallons of filtered aerated water.
    - Housing-Larvae
        - Filtration
            - Mechanical, chemical and biological filtration is essential to maintain water quality. UV sterilizers may also be beneficial.
            - External canister filters are best for maintaining high volumes of water and moderate to high stocking densities. Under-gravel filters and filter sponges are best suite for low water volumes and low stocking densities.

            - Even with filtration, water changes are important to reduce build-up of organic waste product. Approximately 10 percent of the water volume should be changed weekly.
            - Systems that include algae growth and living plants are encourage as it provides additional buffering of water quality parameters. Additionally, algae are excellent food for larvae.
        - Stocking density
            - Sizes can be mixed; with Chiricahua leopard frogs there is no evidence that large tadpoles harm small individuals. Stocking capacity declines as tadpoles grow larger, so it is important to monitor water quality closely and check for signs of overcrowding.
            - For maximum growth
                - 25-30 larvae per 10 gallons of filtered aerated water
    - Housing-Metamorphosing Larvae
        - Water depth should be decreased to no more than 5 inches for larvae showing hindlimbs only.
        - Edges of the enclosures should have haul out areas and underwater perches. Some larvae may drown swimming the perimeter of the enclosure looking for haul out areas of none have been provided.
        - Cover should be provided on dry land and underwater.
        - Some haul out areas should be beneath a basking light.
            - Wattage of light should be adjusted to provide a hotspot of 85-90°F
        - Larvae that have developed 4 legs but retain a tail should be maintained in a separate tank from the 2-legged larvae. The water level can be decreased to 3 inches or less to reduce risk of drowning.
        - Newly metamorphosed froglets should be separated by size to keep cannibalism to a minimum. Although larvae are not cannibalistic, juvenile and adults frogs are.
        - Stocking density:
            - No more than 10 metamorphs or froglets per 10 gallons of filtered aerated water.

- Diet
    - Many of the problems with metamorphosis are due to poor plane of nutrition as a tadpole. Mistakes during tadpole development may result in dying tadpoles, stunted metamorphs or froglets that are unthrifty.
    - Leopard frog tadpoles typically graze off the bottom of the water column or on the surface of objects. Food should be placed on the bottom of the enclosure to ensure the tadpoles find it easily. Some food items are buoyant, such as thawed frozen spinach, and may need to be weighted with stones so they don't float.
    - Type of food for larvae:
        - Live algae and aquatic plants are excellent food sources for tadpoles.
            - Where possible, enclosures should be heavily planted so that tadpoles can graze of live food plants.

        - Duckweed (*Lemma*) is easy to raise and a good food source. It may need to be harvested and crushed to sink to the bottom of the enclosure where it is easily found by tadpoles.
        - Other aquatic plants are useful food sources (e.g., *Elodea*)
    - If it is not practical to maintain algae and live plants in the rearing enclosures, algae cultures can be started in other enclosures and used as a food source.
        - Firm plastic sheets, pieces of tile or nonporous stone may be placed into an algae-rich environment and seeded with algae. Once a layer of algae is growing, the "plot" of algae can be removed and placed in with the tadpoles for grazing.
        - If multiple plots are maintained, fresh algae is available for harvesting continuously.
- Larvae feed well on dark green leafy produce
    - Dark green leafy produce should not exceed 50 percent of the total diet offered
        - Spinach
            - Use either frozen thawed spinach or fresh spinach that has been frozen overnight. Freezing breaks down the cell walls of the spinach and makes it more digestible by the tadpoles.
            - Spinach contains oxalates that can interfere with tadpole development if consumed to excess. Spinach should comprise no more than 15 percent of the diet offered
            - Spinach is not an essential part of the diet, merely an option!
        - Romaine lettuce
            - Should be frozen overnight to break the cell walls and increase its digestibility
            - Romaine lettuce should comprise no more than 15 percent of the diet offered
        - Mustard greens
            - Should be frozen overnight to break the cell walls and increase its digestibility
            - Mustard greens should comprise no more than 15 percent of the diet offered
        - Turnip greens
            - Should be frozen overnight to break the cell walls and increase its digestibility
            - Turnip greens should comprise no more than 15 percent of the diet offered
    - Other produce may be offered not to exceed 15 percent of the total diet offered
        - Cucumber slices

            - Should be frozen overnight to break the cell walls and increase its digestibility
            - Cucumber should comprise no more than 15 percent of the diet offered
        - Green peas
            - Should be frozen overnight to break the cell walls and increase its digestibility
            - Peas comprise no more than 15 percent of the diet offered
    - Bok Choy and Kale are not recommended as their cell walls seem more resistant to bursting during the freezing process. They have low digestibility for tadpoles.
- Processed fish foods
    - Spirulina-based fish foods and algae wafers designed for herbivorous cichlids work well.
        - They may comprise up to 50 percent of the diet
        - Sinking wafers or pellets are preferred to floating wafers or pellets
    - High protein fish foods should comprise at least 25 percent of the offered diet
        - Dehydrated bloodworms, tubifex worms and earthworms are excellent sources of protein
        - Sinking foods are preferred to floating foods
    - Frozen bloodworms, daphnia (water fleas) and rotifers are excellent protein sources and should comprise at least 5 percent of the offered diet
    - Cooked egg white can be used as a protein source. It should not exceed 5 percent of the offered diet.
    - Alfalfa-based rabbit pellets may be used as a temporary diet if no other foods are available.
- A complete tadpole diet will vary from species to species and depends on water quality in part. However, a good starting diet consists of 5 oz of frozen thawed dark green leafy produce, 2 oz of frozen thawed peas, 5 oz of spirulina algae wafers, 2 oz high protein fish food, 2 oz frozen bloodworms.
    - All of these materials can be mixed together and frozen into small cubes for later use.
    - One 400 mg tablet of human-grade calcium carbonate and one multivitamin tablet should be ground into a powder and mixed into every pound of food.
    - One pound of the diet can be mixed together with hot water and one packet of unflavored gelatin to form more durable cubes that sink to the bottom of the water table
        - This may be kept in the refrigerator (45°F) for up to 5 days
        - If longer storage is desired, freeze the cubes. This reduces the potency of some of the water-soluble vitamins.

        - Food should be offered *ad libitum*. This means that fresh food is constantly available for feeding throughout the entire day and night.
        - Uneaten decomposing food should be removed daily
    - Calcium is a critical supplement for the diet
        - Calcium carbonate blocks or calcium carbonate pills (designed for human consumption) should be scattered on the bottom of the enclosures even if the food has been supplemented with calcium.
        - Calcium hardness of the water needs to be high for most species of native Arizona Leopard Frogs. Calcium supplements used to increase the hardness of water for freshwater tropical cichlids may be used. Ranges of 350-450 ppm are appropriate.
        - Vitamin D3 supplements, such as used for supplementing the water source of feeder chickens, pigs or calves, may need to be added to the water in some instances if the diet was poor.
  - Types of food for froglets and juveniles
    - They feed well on domestic crickets, mealworm larvae, mealworm adult beetles, flightless houseflies, silkworm larvae, earthworms, small fish, and small roaches
        - Food must be offered alive
        - Since frogs often hunt more intensively at night, food items should be introduced to the enclosure at dusk, either just before or just after the lights over the enclosure have been turned off.
        - Insects should be dusted with calcium carbonate prior to feeding to increase the calcium content ingested by the frog
        - Insects should be dusted with a multivitamin powder once a week prior to feeding
    - In open air facilities a black light can be hung near the edge of the pond to attract wild night flying insects. The light should be hung low enough to the ground so the frogs can easily catch the flying insects, but high enough to attract insects from a distance.
        - Do not use this technique if there is a risk that pesticides are sprayed in nearby areas

- Air Quality
  - If the air smells bad to you for any reason, it may contain chemicals that are harmful for amphibians
    - Do not smoke around amphibian enclosures
    - Avoid the use of strong smelling chemicals in the airspace around an enclosure
    - Make sure that the ventilation leading to the amphibian enclosure does not communicate with any space that has dangerous chemicals in the air
  - Water in enclosures should have sufficient aeration so that the larvae are not gasping for air at the top of the tank or looking distressed.

- Water Quality and Changing Schedule
  - The importance of appropriate water for raising young amphibians cannot be overstated. Larval development and metamorphosis are incredibly complex and demanding life stages for amphibians. In addition to diet, some dissolved substances in the water provide nutrients for growth of the larval amphibian. Conversely, some dissolved substances are toxic and create metabolic demands that can interfere with normal growth and metamorphosis.
  - Water samples from natural breeding sites should be analyzed for various parameters and efforts made to reproduce those parameters in the captive setting.
    - Unfortunately, many times there is little or no data about the water quality *in situ*. The guidelines in Table 1 are settings that are applicable to most Leopard frog species native to Arizona.
      - Values should be adjusted if the species is known to inhabit hard alkaline water (e.g., limestone seep) or soft acidic water (e.g., sphagnum bogs, pine forests) or it is likely that larval growth and metamorphosis may be abnormal.
        - For example, Ramsey Canyon leopard frogs, *Rana subaquavocalis*, developed nutritional secondary hyperparathyroidism when maintained in water that had lower calcium hardness than the levels detected in natural breeding sites.
      - Simple dipstick water quality tests are readily available (Hach Company, PO Box 389, Loveland, CO 80539, phone (800) 227-4224).
  - Changing Schedule
    - All holding containers should ideally be cleaned daily by siphoning off a minimum of 10 percent and a maximum of 50 percent of the water in the larvae holding containers, and then replacing it with one of the water types under water quality.
    - The frequency of water changes will depend on the stocking density of larvae and presence/absence of a filtration system.
    - Water for the froglets can be changed once a week to minimize stress as long as dead prey items are being skimmed daily.
  - Water Issues
    - If tap water is used for water, the faucet should be opened and run for a few minutes prior to collecting water. This allows the residual water in the pipes that may have a high copper content to be flushed out of the system,
      - Tap water should be allowed to sit 24 or more hours in an open container to allow the chlorine to dissipate.
      - Aeration helps remove the chlorine quicker.
      - Check with your local water provider. If chloramines are used to disinfect the water, you may need to use dechlorinating chemicals instead of aeration. It may take 3-5 days for chloramines to be eliminated from the water by aeration

- Carbon filters can be placed in-line to eliminate the need for aeration to remove chlorine or chloramines
    - These filters need to be changed regularly
    - Water should be checked with chlorine test kits (e.g., Hach Company dry strips) to make sure the filters are functioning properly

- Stream or pond water from which the animals originated is acceptable.
    - The water temperature may be raised to 95°F or higher to eliminate chytrid fungus

During a water change, replacement water should be the same temperature as the water in the holding container to minimize stress.

Table F1. Water quality parameters suitable for Arizona Leopard Frogs**.**

Parameter	**Range** **Frequency of Sampling**	**Comments**
Temperature	68-74°F Daily	Temperature may be maintained outside these ranges depending on the growth rate desired. Gastrointestinal gas and slow development are signs of inappropriately low temperatures.
pH	7.8-9.0 Daily	Requires at least a 10 percent water change if outside this range. If the pH is outside this range more than 3 days in a row, the filter media may need to be changed. Lower pH to 6.5-7 for acidic species by adding peat moss. Higher pH may be achieved using calcium supplements or water quality supplements for alkaline-dwelling cichlid fish.
Ammonia	Not to exceed 0.2 ppm Daily	If outside this range, change water immediately. Make sure uneaten food and organic debris are being removed frequently. The volume of water to be changed depends on level of ammonia. May need to add Amquel™ or other ammonia-neutralizer designed for tropical fish. Filter may need to be changed and new activated carbon added. Even a minor rise in ammonia can cause immediate death or immunosuppression and subsequent outbreaks of infectious disease. Ideally, ammonia levels should never exceed 0.1 ppm
Nitrite	Not to exceed 0.1 ppm Every 2 or 3 days	Requires at least a 10 percent water change if above this limit. Make sure uneaten food and debris are removed. Filter may need to be changed.
Nitrate	Not to exceed 10 ppm Every 2 or 3 days	Requires at least a 10 percent water change if above this limit. Make sure uneaten food and debris are removed. Filter may need to be changed.

Parameter	**Range** **Frequency of Sampling**	**Comments**
Total Hardness	Not to drop below 350 ppm Every 7 days	Specimens may show white plaques if hardness is too high. Change water and refill with distilled or deionized water if hardness is too high. Add calcium blocks or cuttle bone if hardness is too low. Water supplements designed for hardwater (alkaline) cichlid fish may be used to increase hardness instead.
Calcium Hardness	Not to be less than Total Hardness Every 7 days	See comments for total hardness.
Alkalinity	50-100 ppm Every 7 days	See comments for total hardness.
Free Chlorine	Not to exceed 0 ppm after water change	Chlorine-free water should be used to prepare an enclosure. Any detected chlorine indicates that the carbon filter on the water supply line needs to be changed. Dechlorinating agents such as sodium thiosulfate may be added if it is impractical to change water.
Total Chlorine	Not to exceed 0 ppm after water change	See comments for free chlorine.
Iron	Not to exceed 2 ppm after water change	See comments for copper.

Captive Release Protocol For Larvae, Juvenile and Adult Leopard Frogs Native to Arizona

- Qualifications For A Release Program
  - No mortalities in the release group during the previous 30 days
    - Release groups may be defined as groups of frogs or larvae confined to an individual container, such as a fish tank, at a rearing facility
    - No "cause of death unknown" or diagnosis of contagious disease as cause of death for 30 days prior to release.
    - All mortalities should be examined by a pathologist skilled in diagnosing amphibian diseases.
      - If sections of skin are submitted to the pathologist (instead of the whole animal), the sections should include at least 2 pieces of skin from the ventral pelvic region and/or ventral hind limb and/or feet or toes.
      - Each release group should be screened by PCR tests to identify chytrid fungus at least 30 days prior to release
        - Only chytrid-negative groups should be released
  - No unthriftiness or diagnosed illness in the release group during the previous 30 days.
    - No obvious physical abnormalities – missing limbs, deformities of long bones, vertebral scoliosis or kyphosis, corneal lesions, skin lesions – detected.
    - Diagnosis of certain diseases, such as mycobacteriosis, in a single individual may render the entire group unfit for release.
  - No medical treatments of the release group during the previous 30 days.
  - All animals designated for release should be in permanent quarantine to prevent exposure to novel pathogens.
    - Open enclosures which allow access of free-ranging insects and other food animals are still considered quarantine as long as there is a low risk of other amphibians entering the facility
    - Staff caring for animals known to harbor diseases communicable to leopard frogs (including but not limited to other amphibians) should have no contact with quarantined leopard frogs. If this is not practical:
      - Caregivers should work the leopard frogs first before they have cared for other animals.
      - Caregivers that have contacted other animals either as part of their job or as pets should "shower in" and change clothes before entering the leopard frog facility.
    - If a wild population has a known incidence of a given infectious agent (e.g. Lucke's herpesvirus), it may be safe to assume that released animals with that agent represent an acceptably low risk.
  - All enclosures should be worked with separate tools and equipment to reduce cross-transmission.
    - Disposable gloves should be worn and new ones used for each enclosure.
    - Any enclosures with unthrifty animals should be worked last.
  - Water quality logs should be maintained. Adjustment to release site water conditions should occur 30 days prior to release.

        - Animals that have recently been exposed to ammonia or nitrite spikes within 30 days of may be under substantial stress. Potential impact should be discussed with all parties involved before a release is approved.

- Pre-Release Screening Protocol (Up to 30 Days Prior to Release)
    - Depending on the size and life stage of the specimens to be released as well as the number of specimens destined to be released, a random sample of animals may need to be assessed rather than an individual assessment of all animals within a group.
    - Data to be obtained and evaluated
        - Obtain weight
        - Perform physical exam
            - Note body position
            - Alertness
            - Nose-to-toes visual examination
                - Note any abnormalities
                - Pay special attention to the musculoskeletal system for obvious bony abnormalities (e.g., long bone curvature or asymmetry, spinal curvature, mandibular bowing, etc.).
        - Obtain skin scrape sample for chytrid PCR testing
            - Only animals testing negative within 30 days of release should be released
            - Positive animals should be treated
        - If post-release monitoring is scheduled, mark animal with permanent or temporary technique consistent with goals of monitoring program.
            - Toe clip
                - Toe clip may be saved for chytrid histopathology, DNA banking or frozen for future pathogen recovery attempts.
            - PIT tags
                - Intracoelomic placement may not be permanent
                - Subcutaneous placement may need surgical glue closure of injection site to prevent tag loss
            - Injectable elastomeres

- Pre-Release Activities (10 Days and 2 Days Before Release)
    - Chytrid fungus prophylacis
        - Soak in an antifungal solution 10 days and 2 days prior to release (or packing for transport for release)
            - If this has never been used on this species before, try the treatment on a few individuals well ahead of time to determine tolerance.
            - Use one of the following two treatments.
                - Itraconazole: diluted to 0.01 percent concentration in 0.6 percent saline (Sporanox, Janssen Pharmaceutica, Titusville, New Jersey). Rx: Add 10 ml of a 1% itraconazole solution to 990 ml of 0.6% saline [6 g NaCl added to 1 liter of water]. Soak frogs for 1 hour.

- Miconazole: diluted to 0.01 percent concentration in 0.6 percent saline as alternative (Conofite lotion, Schering-Plough Animal Health Corp., Union, New Jersey) for up to 1 hr. This solution is generally not tolerated as well as itraconazole since it contains alcohol.

- Immediate Pre-Release Activities (At Time of Packing for Transport)
  - Do a visual assessment of animals and approve or reject packing for transport.
  - Antibacterial prophylaxis
    - If this has never been done before, try the treatment on a few individuals well ahead of time to determine tolerance.
    - Dip in benzalkonium chloride (2.0 mg/l). Rx Large batches: Add 0.5 ml of a 50% benzalkonium chloride solution to 125 liters of water [~33 gallons]. Soak frogs for 15 to 20 seconds. Rx Small batches: This is best done in 2 dilutions. 1) Solution A. Add 0.5 ml of a 50% benzalkonium chloride solution to 5 liters of water. 2) 40 ml of solution A to 1 liter of water. Soak frogs for 15 to 20 seconds.
    - Rinse with fresh water before packing animal.
    - Repeat visual assessment and approve or reject for packing for transport

- Activities At Release Site
  - Do a final visual assessment of animals and approve or reject release.
  - Aquatic life stages
    - Equilibrate water temperature and chemistries of transport container with release site water
      - Float containers in release site water for at least 30 minutes
      - Do a 50 percent water change with release site water and wait for 10 minutes
      - Release all animals that appear to behave normally
  - Terrestrial life stages
    - Equilibrate container temperature with release site temperature
      - Sit containers in shaded location for at least 30 minutes
    - Release all animals that appear to behave normally

APPENDIX G

Field Work Disease Prevention Protocol

All resource and land management agencies, researchers, and others conducting aquatic monitoring or research are encouraged to follow this protocol to prevent or reduce the spread of amphibian and other aquatic borne diseases. This protocol for working in wetland habitats is adapted from the Declining Amphibian Populations Task Force Fieldwork Code of Practice, which provides guidelines for use by anyone conducting fieldwork in amphibian or other aquatic habitats. Chytrid fungus, iridoviruses, and other highly contagious and deadly diseases are being reported worldwide, and may be a significant cause of amphibian population declines. Pathogens such as chytrid fungus can easily be transferred between habitats on equipment and footwear of fieldworkers, spreading to new locations containing species that have little or no resistance to the organisms. It is vitally important for anyone involved in amphibian research and other types of wetland studies, including those on fish, bats, invertebrates and plants, to take steps to prevent the introduction of disease agents and parasites. For further Declining Amphibian Populations Task Force information, see http://www.open.ac.uk/daptf/index.htm (website current as of March 2004).

Requirements for Working in Wetland and Aquatic Systems

- Dedicated equipment will be used by staff, crews, and permitees frequently working in springs occupied by Chiricahua leopard frogs. This includes footwear. Dedicated equipment will be cleaned and stored separately.

- Equipment which cannot be duplicated or can be easily cleaned must be disinfected between visits to springs. Equipment will be rinsed and all debris removed. Surfaces, which should appear clean, will be scrubbed with one of the following solutions:
    - 1) rinsing with 1 percent sodium hypochlorite (household bleach);
    - 2) 20-second exposure to 70 percent ethanol or 1 mg/ml benzalkonium chloride;
    - 3) desiccation and exposure to 50-60°C heat for 30 minutes;
    - 4) 0.012 percent Path-X™ or 0.008 percent quaternary ammonium compound 128 (both containing DDAC, didecyl dimethyl ammonium chloride as active ingredient)
    - Solution concentrations from Johnson, ML, L Berger, L Philips and R, Speare. 2003. Fungicidal effects of chemical disinfectants, UV light, desiccation and heat on the amphibian chytrid *Batrachochytrium dendrobatidis*. *Diseases of Aquatic Organisms* 57:255-260.

- Following disinfection, equipment should be rinsed copiously with tap water.

- Footwear belonging to occasional users must be completely cleaned before and between visiting spring sites, with special attention paid to grips, cleats, and laces. Felt-bottomed wader boots are very difficult to clean completely and should be avoided whenever possible. To further reduce the risk of disease transfer, all equipment will be completely

dried before re-use. Bat and bird netting which has remained out of the water does not have to be wetted. Poles and stakes need to be completely cleaned as above. Trowels used to collect plants need to be dedicated or completely disinfected between springs.

- In remote locations, clean all equipment as described above upon return to the lab or base camp. If disinfecting in the field is necessary, sanitize all items before arriving at the next location. Do not use solutions in the immediate vicinity of the springs or in other habitats. Used cleaning materials (including liquids) must be disposed of safely and if necessary taken back to the lab for proper disposal.

- When animals are collected, separation of specimens from different sites will be ensured and great care taken to avoid indirect contact between them (e.g. via handling, reuse of containers) or with other captive animals. Isolation from unsterilized plants or soils that have been taken from other sites is also essential.

- Amphibians that are headstarted for release into refugia will be grown using clean lab methods (i.e., quarantine) and disinfected prior to release.

APPENDIX H

Watershed and Channel Processes that Support Aquatic and Riparian Ecosystems and Chiricahua Leopard Frog Habitat

Hydrologic and geomorphic processes (groundwater, surface water, channel, and watershed processes) are intricately related to the form, function, and condition of aquatic and riparian ecosystems – ecosystems that provide essential suitable habitat for the Chiricahua leopard frog. This Appendix explains the watershed framework and its relevance to Chiricahua leopard frog recovery; discusses suitable habitat for the Chiricahua leopard frog in terms of the hydrologic and geomorphic processes that sustain such habitat, the natural ranges of variation in these processes, and the human-induced changes that have occurred to these habitats. We also summarize pertinent watershed and stream assessment methodologies, provide suggestions on how to prioritize sites for restoration based on watershed principles, and provide general guidance on how to develop a restoration plan.

Watershed Delineation

Watersheds are drainage basins - portions of the surface that collect runoff from the surface, concentrate it into channels, and conduct the resulting flow to a definable outlet. Simply stated, a watershed is the total area above a given point that contributes water to that point. Watershed concepts are those analytical and management principles for which the application relates directly to a geographic region defined by a drainage area. For many decades, watersheds have been used as a convenient geographic unit for studies of how natural and human-caused activities affect water quality and quantity at specific points on a stream and on particular water bodies (Omernick 2003).

The Chiricahua leopard frog is primarily an aquatic species; hence, watersheds may serve well as regions for analysis, decision-making, and management for recovery of the frog. However, watershed boundaries are permeable – disease, frogs, and water (through artificial transfers) can cross watershed boundaries. A number of extant Chiricahua leopard frog sites are located near watershed divides in headwater areas where relief is small and frogs may easily cross the divide. Watershed boundaries are also permeable in that artificial transfers of water among watersheds are common. Disease vectors also cross watershed boundaries. Therefore, planning and management considerations may need to extend beyond the physical watershed boundaries.

Large watersheds are aggregations of smaller watersheds, producing a natural hierarchy. Definition of the watersheds and river basins of the Southwest is standardized among Federal and state agencies by the National Water Resources Council and the U.S. Geological Survey, who have created a series of watershed outlines (U.S. Water Resources Council 1978). This standard approach uses a hierarchical series of numbered hydrologic units (HUs), with each unit being a watershed, a part of a watershed, or a collection of watersheds (Seaber *et al.* 1987). The identification numbers, called hydrologic unit codes (HUCs), use two digits for the largest divisions or regions, four digits for subdivisions, and six, eight, ten, and, in some locations, 12 digits for still finer subdivisions.

The largest divisions in the HU classification system are 21 *water resource regions*, which cover the entire U.S., with each region containing either an entire river basin or a series of closely related basins, each identified with a two digit hydrologic code. The regions covering the range of the Chiricahua leopard frog include the Rio Grande (region number 13), Upper Colorado River (14), and Lower Colorado River (15), though not all of this area is current or historical Chiricahua leopard frog habitat.

The creators of the HU maps subdivided the water resource regions into *planning subregions*, designated with 4-digit code numbers; 6-digit code numbers identify the members of a still finer subdivision consisting of *accounting units*. The accounting units are divided into smaller subdivisions, or *cataloging units*, identified by 8-digit code numbers. The 21 water resource regions of the nation contain 2,150 of the 8-digit units, which have an average drainage area of about 1,750 km2 (700 mi2). These units provide a standardized base for use by water-resources organizations in locating, storing, retrieving, and exchanging hydrologic data; in indexing and inventorying hydrologic data and information; in cataloging water-data acquisitions activities; and in a variety of other applications (Seaber *et al.* 1987). Other agencies, particularly the Natural Resource Conservation Service, have divided the 8-digit cataloging units into 10-digit hydrologic units, known as 10-digit HUs (formerly known as 11-digit HUs) (http://www.az.nrcs.usda.gov/technical/gis/index.html). The hydrologic units shown on maps, as delineated by this hierarchical subdivision, are commonly referred to as HUCs, even though the codes are merely identifiers for the units at their particular hierarchical levels (Omernik 2003). It is more accurate to refer to the hydrologic units as HUs.

Ten-digit HUs are the smallest widely-available subdivision. Although the term HU and watershed may be used interchangeably in this recovery plan and were often used in delineation of RUs and MAs, it must be remembered that HUs are not in all cases true watersheds, but may be a part of a watershed, with flow into the HU from upstream areas. Because of the aforementioned permeability of watershed boundaries – to disease, to water transfers, and sometimes to frogs themselves - RU and MA boundaries do not always correspond to watershed boundaries.

Reviews of water-related resource management by the National Academy of Sciences (National Research Council 1999) and by a Presidential commission on western water (Western Water Policy Review Advisory Commission 1998) recommend watersheds as the spatial framework for planning and management of water and water-related resources. Though the utility of using watersheds for study of land/water relationships is apparent, watersheds as an ideal unit for ecosystem management is not as well understood and may be inappropriate (Omernik 2003). Omernik (2003) points out that the choice depends on what one is studying and on the objectives of the study, and notes that the strength and limitations of watersheds and HUs must be clarified and understood.

Watersheds can be used as an analytical and management unit when the physical system makes sense to do so. Regardless of the management unit, it is a fact that land and water uses that occur upstream from a site have the potential to alter the hydrologic regime at the site - i.e. water and sediment delivery - in ways that may be either detrimental or beneficial to the frog and its habitat. Land and water uses that occur within a one-mile radius of a site - both upstream and

downstream and across upland areas – are likely to have the most immediate effect and require strong examination as there may be either negative or positive consequences to frog populations and habitat.

In the past several years, frogs have been observed, and are believed to still occur, in 42 different 10-digit HUs – 24 HUs in Arizona and 18 HUs in New Mexico. Historically, including all documented observations, frogs occurred in 95 different 10-digit HUs in the U.S. – 49 in Arizona and 46 in New Mexico. Historical data go back to the 1920's, though most of the observations were made from the 1970's to the present. Frogs were probably more widely distributed in pre-European times than is indicated by these historical observations.

Management Areas (MAs)

MAs have been delineated in Arizona and in New Mexico (see Appendix B). Two MAs have also been delineated entirely in Sonora, and others straddle the Arizona-Sonora border. In some cases, MAs correspond to 10-digit HUs and in other cases, MAs may consist of only part of a 10-digit HU or may span parts of several 10-digit HUs. In New Mexico, the entire 10-digit HU containing occupied and potential habitat was typically designated as the MA. In Arizona, MAs were often delineated as parts of a HU or HUs. MAs in relation to occupied 10-digit HUs are shown in Figures H1 and H2, which also show sites with frogs likely present.

There are 36 MAs in the U.S. and two entirely in Mexico. In the southern U.S. portion of the frog's range, there are 16 MAs that range in size from 98 to 268 square miles (Figure H1). In the northern portion of the frog's range, there are 20 MAs that range in size from 68 to 909 square miles (Figure H2). MAs delineate those areas where the recovery team believes there is large potential for successful recovery. MAs contain extant populations or sites where habitats will be restored or created, and populations of frogs established or reestablished.

To examine more closely the relationship between MAs and watersheds, we will use MA 2 (MA2) – the Pajarito Wilderness – as an example. MA2 is in Recovery Unit 1 and crosses the U.S.-Mexico (Arizona-Sonora) border (Figure H3, Map 1). In the U.S., MA2 corresponds to the 10-digit hydrologic unit known as Rio Altar Headwaters, which contains the Sycamore Creek watershed (Figure H3, Map 2). The Sycamore Creek watershed is an important location for extant Chiricahua leopard frogs, which most likely functions as a hub of a metapopulation. Thus, the Sycamore Canyon watershed is an important area for protection of existing frog populations and may contain locations of suitable habitat that are currently not occupied but could support reestablished populations. When one looks closely at the Sycamore Canyon watershed, it can be seen that smaller nested watersheds can be delineated for each extant population (Figure H3, Map 3). For instance, activities in the relatively small watersheds of two occupied stock tanks in the Sycamore Canyon watershed (85 and 32 acres – see delineated watersheds in Figure H3, map 3) can have the most direct impact on the frogs and their habitat, whether those activities consist of natural ones (e.g. flooding and sedimentation) or human-induced (e.g. mining, road construction). Although MA1 is the area delineated for management purposes, each individual site should be considered in the context of its immediate watershed.

Frogs currently often occur at springs and stock tanks that are in the upper reaches of watersheds, where the local watershed is small and thus fairly isolated – i.e. there is little upstream area. These populations may be the easiest to control, with respect to upstream impacts. However, there are numerous populations, some in Arizona and more in New Mexico, that are still extant in stream systems that have appreciable upstream watershed area. For example, the population that occurs in the main stem of Sycamore Creek has an upstream watershed area of about 4,600 acres. The population that occurs on the middle San Francisco River has an upstream watershed area of over 1,200 square miles. Although all upstream activities have the potential to affect water and sediment delivery at a particular site, the nearer an activity occurs to a site, the larger is the potential to affect the site. It is true that management may be simpler for a site with a 32-acre watershed than for a site with a 1,200-square mile watershed. This is, no doubt, a major reason that remaining Chiricahua leopard frogs occur in relatively isolated locations near the headwaters of stream systems. However, it is important to maintain and recover populations in small watersheds as well as larger watersheds. Numerous local populations scattered through a relatively large watershed area can function as a metapopulation, and protection and reestablishment of such populations is important to recovery.

WATERSHED PROCESSES

The term watershed processes, in its simplest form, refers to rainfall-runoff processes. However, there are a host of interconnected processes occurring at the watershed scale. The section below briefly describes these processes and provides references for additional reading.

Runoff Processes and Streamflow

Precipitation falling to the Earth may evaporate, be transpired by plants, infiltrate the soil surface and percolate downward through the soil profile to become subflow to perennial streams or to recharge groundwater aquifers, or it may runoff the surface and be converted to streamflow. In the southwestern U.S., only about 5 to 15 percent of average annual precipitation is converted into streamflow (Ffolliott *et al.* 2004). In well-drained forested watersheds in mesic regions, such as the eastern U.S., precipitation tends to move vertically into the soil profile and then laterally through the soil to stream channels. In the Southwest, vegetation is sparse, soils are shallow with low permeability, and high-intensity rain storms often exceed the infiltration capacities of soils, making overland flow the dominant process in moving excess water into stream channels (Marti *et al.* 2000). Rapid water level rises in streams recharge dry streambeds, resulting in large transmission losses, i.e. losses of streamflow to bank storage and channel bottoms when streamflow is first initiated in intermittent or ephemeral streams. Bank storage is also an important process on perennial streams, when flood flows raise the water level much higher than normal base flow, recharging the floodplain.

Although groundwater does not respond as quickly to precipitation as does streamflow, because of the longer pathways involved, rapid water level rise may occur following a precipitation and streamflow event in areas with shallow groundwater. Rapid water level rise is observed beneath an ephemeral reach of the San Pedro River, Arizona, following flow events in the river (Figure H4). When groundwater level is sufficiently high to intersect the bottom of a stream channel,

groundwater discharge to the stream channel occurs. If groundwater discharge to the stream occurs year round, the stream is said to be perennial. If groundwater discharge to the stream occurs in some seasons, but not year round, the stream is said to be intermittent. Ephemeral streams are those that flow only in direct response to surface water runoff; i.e. the top of the groundwater (water table) does not intersect the bottoms of ephemeral stream channels. In some cases in arid regions, the top of the groundwater may be several hundred feet below the bottom of ephemeral stream channels (i.e. washes). Typically, in valley bottoms in regions without large-scale groundwater development by humans, the groundwater either intersects the bottom of the stream channel or occurs at a fairly shallow depth beneath the stream channel. In valleys with shallow groundwater but without perennial streamflow, groundwater may still be sufficiently shallow to provide sub-irrigation to the deeper-rooted vegetation.

The larger the watershed area, the greater the volumes and peak flows of streams and rivers (Baker 1986). Round watersheds, as opposed to those that are more elongated, concentrate rainfall-induced streamflows more quickly at the outlet, so there is little difference between rainfall-induced streamflows and those from snowmelt. Streamflow response to rainfall is quicker and peak flows are higher on high-elevation watersheds with steep hillslopes and channel gradients than on low-elevation watersheds with gentle hillslopes. Amounts and rates of overland flow from rainfall storms are higher on watersheds with soils of volcanic origin than on watersheds with sedimentary soils (Ffolliott *et al*. 2004). The greater the intensity and the longer the duration of rainfall, the higher the magnitude of the resulting streamflow. When soils in a watershed are already wet from an earlier rainfall event, subsequent events produce a greater volume of streamflow than a comparable precipitation event would produce on a dry watershed.

Snow melt events at high elevations are a major contributor to annual streamflow (Baker *et al.* 2000). Flow response to snowmelt in intermittent and ephemeral streams can last for several days or weeks. Rain-on-snow events, while major streamflow generators when they occur, represent less than 10 percent of the individual streamflow generation events in the Southwest region (Ffolliott *et al*. 2004).

Precipitation and watershed characteristics combine to affect the magnitude and duration of streamflow response. Human activities can result in changes to watershed and stream channel conditions, which can affect streamflow response.

Erosion and Sediment Transport

Stream channels evolve to transport the water and sediment delivered to them by their watershed. On the long journey from watershed divides to the oceans, all rivers must transport the erosional products of their source basins, while maintaining their own competence for self-perpetuation. As the drainage or watershed areas enlarge, so do the requirements for streamflow and sediment transport.

Upland erosion processes, streambank erosion, and channel scour produce the sediments that are entrained in streamflows. Dynamic and complex fluvial processes and hydraulic factors are involved in the intermittent transport and deposition of sediments. The episodic transport of sediments through stream channels in the Southwest mirrors the episodic streamflow patterns

typical of the region (Lopes *et al.* 2001). Although the energy available from snowmelt-runoff events to move soil particles is relatively low, much of the annual total production of sediments is a result of these events. The largest sediment loads transported in single hydrological events are associated with the high-intensity, short-duration and mostly convectional rainfall occurring at all elevations during late summer to early fall. Streamflow duration in these events is typically limited to hours or at most a few days.

Sediment transport in a stream is comprised of two components: suspended sediment and bedload. Bedload is that portion of the sediment load that is too large to be carried in suspension by a given flow, and thus moves along the bottom of the stream in a bouncing sort of motion. Although as much as 90 percent of the total sediment load that moves through stream systems in the Southwest region is comprised of suspended sediments (Ffolliott *et al.* 2004), the bedload component is more important in the structure and function of a stream (DeBano *et al.* 1996). Downstream movement of bedload involves channel erosion and sediment deposition, which affects the stability of the channel. In the Southwest, the transport of sediment in streams and rivers is characterized as alternating pulses of aggradation (deposition) and degradation (erosion) that are punctuated by periods of inactivity (Ffolliott *et al*. 2004).

Riparian Vegetation Dynamics

Riparian zones provide key services for all ecosystems, but are especially important in dry regions, where they provide the main source of moisture for plants and wildlife, and the main source of water for downstream plant, animal, and human communities. These services are highly dependent on streambanks and floodplains being in a vegetated and relatively undisturbed state (Belsky *et al.* 1999). A healthy riparian area maintains a dynamic equilibrium between the streamflow forces acting to produce change and the vegetation, geomorphic, and structural resistance to this change (Baker *et al*. 2004). Topography of the riparian corridors is rearranged during alternating cycles of deposition and erosion, precluding the development of a stable organic soil horizon or a well developed soil profile, and resulting in a soil that reflects the depositional patterns and history of channel flows. Rooted streamside plants retard streambank erosion, filter sediments from the water, build up and stabilize streambanks and streambeds, and provide shade, food, and nutrients for aquatic and riparian species. Healthy riparian areas act as giant sponges during flood events, raising water tables and maintaining a source of streamflow during dry seasons. The result is a more stable streamflow throughout the year (U.S. General Accounting Office 1988).

Disturbance

Riparian ecosystems are subject to and have evolved with extreme natural disturbance. This disturbance, in the form of large floods transporting large sediment loads, are necessary to the recruitment of riparian vegetation, the rewatering and recharge of floodplain sediments, and the maintenance of off-channel wetlands. When a riparian ecosystem is functioning in a stable channel balance between channel deposition and downcutting by erosion, this is termed dynamic equilibrium or stable channel condition (Lane 1955). The variables in this process are sediment discharge, stream discharge, particle size, and channel slope. A change in any one of these variables sets up a series of mutual adjustments in the companion variables with a resulting

direct change in the characteristics of the river. When a riparian ecosystem is functioning in dynamic equilibrium, it is sufficiently stable that compensating internal adjustments occur among these variables without producing changes that overwhelm this equilibrium, i.e. the channel is able to transport the water and sediment delivered to it by its watershed without undue erosion or deposition. Because of the episodic nature of streamflow and sediment transport in southwestern watersheds, local deposition or erosion may occur in short stream reaches while a plug of sediment is being moved through, but overall, the stream is maintaining dynamic equilibrium.

Cattle cause more damage to riparian areas than their often small numbers would suggest. Cattle tend to avoid hot, dry environments and congregate in wet areas for water and forage. Damage caused by cattle to riparian areas and stream habitats in the Southwest can be separated into those that occur at the stream reach level and those that occur at the watershed or regional level (Belsky *et al.* 1999). Excessive grazing by livestock has depleted the herbaceous cover of forage plants and affected the regulating effects of vegetation on soils, streamflow, water quality, and fluvial geomorphology in some riparian corridors (DeBano *et al.* 1999; Cartron *et al.* 2000; DeBano *et al*. 1996). Effects of grazing on aquatic habitat include increased sedimentation, which may fill pools and bury riffles, reduction of streambank stability and hence loss of undercut banks, loss of streamside vegetation, and widening and shallowing of the stream channel – all these influences result in decreased heterogeneity in aquatic habitat.

Livestock grazing has been reduced or largely eliminated from many riparian corridors on public lands in the U.S. However, these corridors are still affected by elk and other ungulates. Where excessive livestock grazing has occurred in the past but has been removed, the stream channels may still be recovering from the effects of that grazing and may still show instability.

Wildfires occurring in the surrounding watershed may spread to riparian areas. Under severe conditions, wildfires can cause widespread damage to vegetation and soil and thereby disrupt the hydrologic function of riparian systems, even if fire did not directly burn in the riparian area (DeBano *et al*. 1998). Storm runoff increases following a fire because of greater contribution from overland flow, which is increased due to loss of cover and reduced infiltration. Peak flows after burning have increased 500 to 2,500 percent in ponderosa pine forests (Campbell *et al.* 1977; Rich 1962) and 20 to 45,000 percent in chaparral shrublands (Sinclair and Hamilton 1955; Glendening *et al.* 1961). Increased peak flows and entrained sediments often overwhelm the dynamic equilibrium of a stream system, causing excessive erosion in higher gradient areas and excessive deposition in lower-gradient areas. Channels and banks may be scoured, floodplains rearranged, vegetation removed, pools filled in, riffles buried, and high turbidity may result in perennial streams downstream from locations of catastrophic wildfire. As the watershed revegetates and soils stabilize, peak flows will reduce and the channel will gradually restore itself to a new dynamic equilibrium.

Hydrologic and Geomorphic Underpinnings of Suitable Habitat for the Chiricahua Leopard Frog

Although the Chiricahua leopard frog is, within the realm of aquatic beings, a habitat generalist, it has been increasingly relegated to an increasingly narrow habitat niche. Caught between the

massive loss of habitat that has historically occurred on the large river systems (due to the human-induced drying of these systems and the invasion of the remaining waters by non-native predaceous species) and the more recent drought induced drying, the frog has been eking out a living in the remaining smaller creek, spring, and stock tank systems. These systems often exhibit poor conditions (due to various human uses) and may be subject to occasional drying, especially during drought years. In fact, in many parts of southern Arizona and the "boot heel" of New Mexico, the highly arid portion of its range, the frog is currently found predominantly in artificial features, such as stock tanks, drinkers, and spring boxes. In the relatively wetter portion of its range, the eastern Mogollon Rim area of Arizona and the Gila Mountains of southwestern New Mexico, frogs occur in higher proportions in natural habitats, as well as in artificial features.

The occasional drying episodes, if of short duration, may benefit the Chiricahua leopard frog because they are slightly more resistant to drying than are bullfrogs and certainly more so than non-native predacious fish species. However, Chiricahua leopard frogs are not highly resistant to drying themselves; therefore, complete loss of moisture from their environment can cause loss of frog populations.

There is a strong desire among many of those involved in ranid frog conservation and recovery to get them back into a more natural environment, in part because natural systems have a higher drought tolerance, tend to be self-sustaining, and can often support larger populations than small artificial systems such as stock tanks; which bodes well for species longevity and recovery, and also because the ability of the frog to sustain itself in a natural environment is a strong indication of the health of that environment. The task is daunting; however, considering the scarcity of water, the current condition of many of the watersheds and their associated channels, the multiple use mandate of public land, the scarcity of funding for restoration, and the conflicting needs and values within the land management agencies and among the public land users.

The Chiricahua leopard frog had most probably disappeared from much of its historical range by the time biologists starting looking for it (see Reasons for Listing/Treats – Degradation and Loss of Habitat, page 33). On the big river systems in Arizona (the Colorado, Salt, Verde, and Gila rivers), 90 percent of natural (unregulated) perennial flow has been lost (Figure H5) due to damming, diversion, groundwater pumping, and watershed and channel degradation. Throughout Arizona, including creeks and streams at higher elevations, at least 35 percent of natural perennial flow has been lost (Figure H5). Such massive loss of flow and associated habitat took a toll on native species, including ranid frogs. The introduction of predatory non-native species, such as American bullfrog and various sport fish species, to the remaining permanent water in the remaining large, bottomland river systems and cienegas essentially destroyed those systems as ranid frog habitat, too, leaving only the higher elevation tributary streams and a few isolated pockets in bottomland systems as refugia.

Beginning in the late 1800s, morphology of bottomland rivers underwent a marked change. In many locations, meandering, marshy stream bottoms became incised - resulting in increased stream gradient, increased erosion, and lowered groundwater levels - with the resultant destruction of many off-channel wetlands and headwater cienegas and associated habitats (Hendrickson and Minckley 1984). These low-energy off-channel and headwater habitats were

most likely the preferred habitat for Chiricahua leopard frog, allowing for a diversity of micro-habitats, protection from predators, and relative habitat stability for egg-laying and tadpole and metamorph development. Evidence of such habitat preference may be seen among lowland leopard frogs, a closely related species, at locations such as Aravaipa Creek in the Aravaipa Wilderness and Hot Springs Creek in the Muleshoe Cooperative Management Area – when walking the main flowing creek, few frogs are seen, but when one encounters quite, stable off-channel pools, leopard frogs abound.

Given the habitat changes, the multiple use mandates of public lands, the private property rights of private lands, and limited budgets, how do we best go about Chiricahua leopard frog recovery – protection and restoration of habitat - from a hydrological and geomorphological perspective?

STREAM AND WATERSHED ASSESSMENT

Riparian and aquatic ecosystems are strongly influenced by the diversity and health of surrounding upland ecosystems. Assessment of watershed conditions, including hydrological sub-basin conditions, is a fundamental component of riparian management (Garrett *et al.* 2002). Numerous guidance documents have been developed pertaining to assessment of bottomland ecosystems - channel, riparian habitat, and watershed conditions. Each governmental agency – the USFS, BLM, U.S. Environmental Protection Agency, NRCS, and NPS – has their preferred methods. Attachment 1 at the end of this appendix provides a summary of some of the available guidance documents. There is no one method that is superior to all the others. It is recommended that any assessment method that is used consider criteria (indicators) that can be used to prioritize riparian habitat management, recognizing four major categories of criteria that influence riparian/fluvial ecosystem management: hydrology (including geochemistry and geomorphology), ecological health, cultural resources, and socio-economic variables.

Sites considered for recovery should provide or have the potential to provide, through habitat restoration or creation, “suitable” habitat for Chiricahua leopard frogs. Suitability is defined in the glossary (Appendix K), and further described in “Habitat Characteristics/Ecosystems” in Part 1; and Attachment 1 of Appendix E.

Stream and watershed assessments may be undertaken for any number of purposes including, but not necessarily limited to, fisheries management, threatened or endangered species recovery plans, drinking water source assessment, watershed/land-use planning, compliance monitoring for State or Federal permits, or for reporting and documenting the status and trends affecting local, regional, or national water quality and stream habitat. With respect to Chiricahua leopard frog recovery, stream and watershed assessment may be undertaken to establish the condition and trend of watersheds or stream reaches that contain occupied habitat; to delineate the extent, condition, and trend of watersheds or stream reaches that support suitable but unoccupied habitat; to prioritize watersheds or stream reaches for reintroduction; and to assess the extent of stream enhancement or restoration projects that would be required prior to reestablishment.

There has been a proliferation of stream assessment protocols in recent years, which attests to the varied needs of resource managers nationwide and the lack of definitive characteristics available to guide the development of such protocols. Although the range of the Chiricahua leopard frog

is restricted to the Southwest, and thus limits to some extent the climatic, hydrological, and geological variation (as compared to nationwide), nonetheless, there is substantial variation in these components across its range. In addition, different management agencies – such as the USFS and the BLM – have developed different stream and watershed assessment protocols, which are documented in specific guidance documents (see list).

In a review of selected physical stream assessment protocols for use in the Clean Water Act Section 404 program, Sommerville and Pruitt (2004) suggested that programmatically complete stream assessment protocols have the following characteristics:

1) Classification: Stream assessment should be preceded by classification to narrow the natural variability of physical stream variables. Classification should be based on intrinsic resource characteristics affecting the physical, chemical, and biological attributes of streams. Pertinent characteristics may span numerous scales including regional, watershed, stream reach, and site specific factors.

2) Objectivity: The assessment procedure should remove as much observer bias as possible by providing well-defined procedures for objective measures of explicitly defined stream variables.

3) Quantitative Methods: The assessment procedure should utilize quantitative measures of stream variables to the maximum extent practicable. If stream quality indices are used, they should be based on explicit values or narrowly defined ranges of quantifiable stream characteristics.

4) Fluvial Geomorphological Emphasis: Stream assessments undertaken to prioritize watersheds or stream reaches for management, or to aid in the design of stream enhancement or restoration projects should be based on fluvial geomorphic principles. In-stream modifications undertaken in the absence of a firm understanding of hydrology and sediment transport, and the resultant implications on channel form can only lead to haphazard success at best, and may result in gross channel instability and degradation that can adversely affect the entire drainage network.

5) Data Management: Data from stream assessments should be catalogued by designated entities in each region of the country. This is especially true of reference data. Many state agencies maintain databases for ambient monitoring and designated use allocations, but these data may not always be shared or utilized by CWA Section 401/404 personnel even within the same agency. Regional or national compilations of stream assessment data would enhance the science of fluvial restoration by providing a more complete picture of physical stream characteristics, and would thereby improve design and review of stream enhancement or restoration projects.

Prioritization

Limited funding requires prioritization. Prioritization requires assessment and a process for selecting the “low-hanging fruit” first. It is important to select the sites where success can be demonstrated, and thus additional funding secured, before moving on to the more difficult sites. Prioritization often involves developing and using specific criteria or indicators and ranking those criteria.

For example, to provide guidance in selecting critical riparian areas in the Little Colorado River Basin, Garrett *et al.* (2002) describe methods for prioritizing riparian management based on geographic analyses of hydrological sub-basin conditions, using the Little Colorado River (LCR) basin in central, eastern, and northeastern Arizona as a test case. They first developed criteria (indicators) that can be used to prioritize riparian habitat management, recognizing four major categories of criteria that influence riparian/fluvial ecosystem management: hydrology (including geochemistry and geomorphology), ecological health, cultural resources, and socio-economic variables. They then described the availability and quality of natural resource data for the LCR and recommend further GIS analyses that would improve the prioritization approach. Next, they used a geographic information system (GIS)-based approach to assessment of ecological conservation priorities in the LCR. They identified 19 ecological and economic criteria for which sufficient data were available and that were good indicators of sub-basin characteristics. They categorized the various LCR hydrological sub-basins, based on amount of perennial and ephemeral stream habitats, vegetation type, and flow modification. They segmented the LCR basin into sub-basins of various sizes, divided resources into environmental and economic categories, standardized variables for sub-basin land area (where appropriate), and used GIS analyses to develop a spreadsheet-based scoring process that generates a score for each resource for each riparian/fluvial sub-basin. They applied the scores to evaluate trade-offs in ecosystem protection and restoration potential, against reaches for which economic or other management actions are appropriate, or on which further research is needed.

Riparian management in sub-basins with multiple-use conflicts may require innovative adaptive management approaches for protection and restoration that bring stakeholders together to develop common economic and environmental goals.

WATERSHED USE AND MAINTENANCE GUIDELINES

Recovery Action 1.2.1 specifies development of watershed use and maintenance guidelines for watersheds containing extant populations of Chiricahua leopard frogs. Extant populations are those considered likely to be present (see Figures H1 and H2 for MAs with likely extant populations) and such watersheds are termed occupied watersheds. These recommendations may also be used to develop guidelines for historically occupied watersheds that are not likely to contain extant populations of Chiricahua leopard frogs but that do contain suitable habitat and potential recovery sites.

Watershed use and maintenance guidelines will be developed by land managers, landowners including ranchers, and other interested parties and are to be specific to an occupied watershed or groups of watersheds. The purpose of the guidelines is to reduce threats and increase persistence of Chiricahua leopard frog populations and metapopulations in specific watersheds or groups of watersheds with the ultimate goal of delisting of the species.

These recommendations are provided to assist land managers, ranchers, and others to develop the guidelines for occupied watersheds in their area. Watersheds (10-unit HUs) were selected as the primary criteria for MA boundaries and therefore serve as useful units when discussing

individual populations and metapopulations of frogs (i.e. “recovery sites” where Chiricahua leopard frogs are likely present or locations selected for future reestablishments).

Land and water uses that occur upstream from a site have the potential to alter the hydrologic regime at the site - i.e. water and sediment delivery - in ways that may be either detrimental or beneficial to the frog and its habitat. Land and water uses that occur within a one-mile radius of a site - both upstream and downstream and across upland areas - may have either negative or positive consequences to frog populations and habitat. With appropriate watershed use and maintenance guidelines, positive benefits can be maximized, and threats to the frog can be eliminated, minimized, or mitigated. Land uses in occupied watersheds and unoccupied watersheds with suitable habitat should strive to maintain habitat, balance the hydrological regime, maintain dispersal corridors, prevent or mitigate the introduction and spread of non-native predators and disease, and minimize or mitigate introduction of contaminants harmful to the frog.

These recommendations provide specific suggestions for minimizing the effects of various land and water uses, predation, and air and water contamination, and provide recommendations for habitat preservation. These recommendations will be valuable when developing watershed use and maintenance guidelines, developing conservation measures for development projects, during section 7 consultations under the ESA, and for regional conservation planning for the Chiricahua leopard frog.

Guidelines should:

1. Permanently protect suitable habitat and dispersal corridors through land acquisition or conservation easements, or other agreements with willing landowners on private lands or water-right holders on private or public lands, and commitments for appropriate land management on public lands.
2. Restore hydrological regime through watershed management, retirement of stream diversions, and local restrictions on groundwater pumping on public lands.
3. Manage livestock grazing to maximize benefit and minimize detrimental effects to Chiricahua leopard frogs.
4. Manage for minimal impact, or eliminate where necessary, activities that have the potential to degrade Chiricahua leopard frog habitat in occupied watersheds – grazing, recreation, mining, timber harvest, flood control activities.
5. Minimize opportunities for introduction of non-native predators and disease and conduct non-native predator control where prudent.
6. Eliminate or control point and non-point sources of contamination, and air-borne contaminants where possible, in occupied watersheds.
7. Employ fire management practices (i.e., prescribed burns, emergency fire suppression, and emergency water use) that decrease incidental impacts and increase benefits to the Chiricahua leopard frog.
8. Implement watershed management and protection plans using cooperative agreements and existing incentive programs.

Appendices A and I discuss conservation measures, mitigation, and compensation that can be built into project proposals to minimize effects on the frog and its habitats.

Actions

The Chiricahua leopard frog was formerly distributed throughout the landscape at elevations between about 3,300 and 8,900 feet. However, habitat alteration, introduction of non-native predators, and disease has resulted in a severe reduction in number of occupied areas. Currently, the U.S. Forest Service manages the majority of occupied habitat of the Chiricahua leopard frog. In Arizona, forests with habitat likely to be occupied by Chiricahua leopard frogs include Coronado, Tonto, and Apache-Sitgreaves National Forests. In New Mexico, forests with occupied and likely to be occupied habitat include Gila National Forest and potentially the San Mateo Mountains on the Cibola National Forest. Therefore, watershed management will be especially important on these national forests.

Important habitat also occurs on lands managed by other entities, including the USFWS, the BLM, the State land departments in Arizona and New Mexico, the White Mountain Apache and San Carlos Apache Tribes, and Fort Huachuca, as well as on private lands such as the Ladder Ranch in RU 8 and the Gray Ranch in RU 3.

Forest Service and BLM lands are public lands managed for multiple use, meaning a wide variety of activities may occur on these lands, including grazing, recreation, mining, and timber harvesting. Diversion of stream water for beneficial use occurs as well as groundwater extraction. Each of these activities has the potential to negatively impact Chiricahua leopard frogs and their habitat if not properly managed with the frog's needs in mind. With proper management, frogs can co-exist with these activities on public lands in many situations. In some instances, certain activities (e.g. livestock grazing, mining, recreation, timber harvest, water uses) may need to be eliminated from occupied watersheds for a period of time, to provide frogs and their habitat the opportunity to recover from excessive stresses.

Private lands include some excellent habitat for Chiricahua leopard frogs, especially in southeastern Arizona and southwestern New Mexico. A number of ranchers in this area have formed the Malpai Borderlands Group and are moving ahead with Chiricahua leopard frog recovery actions. Small private land in-holdings are common in the National Forest and BLM lands. Land and water use activities on these parcels may have detrimental effects on downstream populations of frogs and may also disrupt dispersal corridors, but in some circumstances may benefit frogs (e.g. construction of stock tanks).

The actions described below are recommended for incorporation into watershed use and maintenance guidelines. The overarching purpose of the actions is to protect extant populations and to restore riparian and aquatic habitat to favor dispersal into natural habitats and formation of metapopulation dynamics.

These recommendations only partly address the range of activities that may affect watershed values. Other activities, such as livestock grazing, mining, recreation, contaminants, non-native species, and flood control, among others can dramatically affect watersheds. The effects of these

activities (see Part 1, "Reasons for Listing/Threats") and measures to correct adverse effects (especially see Appendix I and the recovery actions) are addressed elsewhere in this recovery plan. Those sections of the document should be reviewed for further ideas and measures for improving watersheds.

1) Permanently protect suitable habitat and dispersal corridors through land and conservation easements or acquisition, or other agreements with, willing landowners.

a. Encourage and assist owners of large tracts of natural lands to develop preserves, conservation banks, and/or mitigation banks. Owners of large tracts of natural land (public and private) should be encouraged to participate in conservation planning by establishing preserves or mitigation banks. The grass bank program practiced by Malpai Borderlands Group and the Gray Ranch, whereby ranchers can use a grass bank during hard times if they agree to a conservation easement of their property, could be applied elsewhere to reduce grazing impacts during drought and to curtail conversion of ranchlands to other land uses that are not compatible with frog recovery. The mitigation bank program for the endangered Pima pineapple cactus (*Coryphantha scheeri* var. *robustispina*) practiced by the USFWS in coordination with Ross Humphreys may have applicability for recovery of the Chiricahua leopard frog, as well.

b. Purchase conservation easements or parcels from willing sellers or develop agreements with willing landowners where acquisitions/agreements may protect existing populations, allow for expansion of metapopulations, protect dispersal corridors, and increase the quantity of protected suitable habitat within the range of the species. Expanding the acreage of protected high quality habitat within each RU will contribute to recovery of the Chiricahua leopard frog by increasing opportunities for dispersal, population expansion, and recolonization. The delineation of MAs (Figures B1-8, Appendix B) provides direction on where habitat suitability and connectivity are considered important for long-term recovery of the Chiricahua leopard frog and where land acquisition or protection would prove most beneficial.

In the "Critical Recovery Needs" in the "Recovery Units" portion of the Plan, and in the RU descriptions in Appendix B, including delineation of MAs (Figures B1-8), several areas have been noted as being very important to the ecological function of adjacent sites that currently support the Chiricahua leopard frog. Long-term protection of parcels in these, and other areas, should be pursued via conservation easements, Habitat Conservation Plans, Safe Harbor Agreements, or other agreements or mechanisms for long-term or permanent protection.

Isolated sites such as stock ponds, which currently comprise the majority of occupied habitat in southeastern Arizona and southwestern New Mexico, are also in need of protection. If there is opportunity for dispersal to suitable natural habitat, dispersal corridors should be provided permanent protection. Opportunities to acquire in-holdings within National Forests should be pursued; vehicles for achieving this may include land exchanges. Again, protection of the watershed, including stream reaches up- and downstream of known populations and adjacent uplands within one mile, will increase the potential for long-term suitability of such sites for the Chiricahua leopard frog.

Traditional fee title acquisition by government or private resource interests is an effective, but expensive, way of protecting resources. Other mechanisms to protect habitat on private lands include: 1) local zoning restrictions that prevent incompatible uses, 2) transfer of development rights, 3) fee title donations, 4) sale or donation of conservation easements, 5) land exchanges, 6) sale and back lease or resale programs with restrictive covenants, and 7) use of existing incentive programs (described in Appendix A). Support and assistance of private landowners in conserving and recovering the frog may be gained by developing economic and other incentive programs (e.g. relief from taxes, tax credits, tax deductible habitat management expenses, and Safe Harbor Agreements).

2) Restore hydrological regime through watershed management, retirement of stream diversions, and local restrictions on groundwater pumping on public lands.

a. Work to improve watershed and channel condition in occupied watersheds. The goal is to maximize water supply to Chiricahua leopard frog habitat while minimizing erosion and deposition. Altered hydrological regimes can result in a multitude of direct and indirect impacts to the Chiricahua leopard frog and its habitat. Negative effects to the frog and its habitat from poor watershed condition stem chiefly from increased flood peaks, reduced base flow, and excessive sediment transport, which may lead to loss of habitat through scouring, sediment deposition, and drying. Poor watershed and channel conditions may result from excessive grazing pressure, especially during drought years; fire suppression and high-intensity fire; prolonged drought; dams and surface water diversions; and groundwater pumping that intersects stream flow.

b. Retire stream diversions and remove dams to secure adequate flows where appropriate for maintenance and restoration of Chiricahua leopard frog habitat. Where frogs occur in natural stream habitats, data should be collected to identify the stream flows needed to restore natural, seasonal flow cycles and thus maintain optimal habitat for protection and recovery of the Chiricahua leopard frog and co-occurring species. Care must be taken to consider the varying needs of co-occurring species and accommodate potential conflicts. Generally, however, native species co-evolved with each other and with the natural hydrological regime and thus should be expected to thrive under conditions of natural flow.

Water flows will vary with climatic cycles and thus may not be consistently maintained, particularly in drought conditions. Therefore, measures should be proposed and agreements implemented to secure the needed flows when diversions, impoundments, or urban wastewater flows threaten the integrity of the hydrological regime.

Where Chiricahua leopard frogs occur in artificial structures, such as stock ponds and drinkers, steps should be taken to maintain a minimum water level and water quality. In times of prolonged drought, water transport via pipeline or tanker truck may be required.

Recovery Team members, land managers, and wildlife agencies should work with water-resource users to evaluate dams and diversions (particularly springs) that are negatively affecting

the extent and suitability of Chiricahua leopard frog habitat, including those that provide stable, permanent water sources for non-native predators. Strategies to eliminate or reduce impacts to the frog should be developed. In particular, removal of dams and diversions may be considered in coordination with and with approval of water-rights holders and land/facility owners when such facilities no longer serve their useful purpose and/or when they could feasibly be replaced by other, less environmentally damaging facilities capable of supplying water of equal or better quality compared to the facility proposed for removal.

> **c. Restrict drilling of new wells where pumping has the potential to diminish stream flow in occupied watersheds.** Entities other than the Forest Service cannot construct and/or test wells on National Forest System (NFS) lands without Forest Service authorization. Tonto National Forest has developed a groundwater policy that has been adopted at the Regional level. The policy states that water supply development that would significantly impact surface water resources will not be allowed.

Applicants wishing to drill new wells on public lands in occupied watersheds should be required to demonstrate that the water development will not cause degradation of Chiricahua leopard frog habitat through lowering of water levels or diminution of stream flow. For existing wells in occupied watersheds, if it appears that pumping is causing harm to Chiricahua leopard frog habitat through lowering of water tables or diminution of stream flow, alternative water supplies should be investigated. The Recovery Team should attempt to work with groundwater pumpers on private lands, when possible, if private wells are adversely affecting Chiricahua leopard frog habitat.

ATTACHMENT 1

Brief Description of Some Published Stream and Riparian Assessment and Classification Protocols

Stream Visual Assessment Protocol. USDA NRCS National Water and Climate Center Technical Note 99-1 1998. This assessment protocol provides a basic level of stream health evaluation. It can be successfully applied by conservationists with little biological or hydrological training. It is intended to be conducted with the landowner and incorporates talking points for the conservationist to use during the assessment. This protocol is the first level in a four-part hierarchy of assessment protocols. Tier 2 is the NRCS Water Quality Indicators Guide, Tier 3 is the NRCS Stream Ecological Assessment Field Handbook, and Tier 4 is the intensive bioassessment protocol used by your State water quality agency.

Stream Management. U.S. Army Corps of Engineers ERCD/EL SR-W-00-1 2000.
A handbook designed to provide guidance to cities, counties, federal and state agencies, private consultants, private developers, and others. Purpose of handbook: produce projects that have less adverse effect on the aquatic environment.

Hydrogeomorphic Approach for Assessing Wetland Functions. U.S. Army Corps of Engineers, Classification.pdf-1993 Approach.pdf-1995. A multi-agency effort involving the Corps, EPA, the Federal Highway Administration, NRCS, and the USFWS; developed primarily for use in the context of the Clean Water Act Section 404 regulatory program. The HGM is a procedure for measuring the capacity of a wetland to perform functions. This narrows the focus of attention to the functions a particular wetland type is most likely to perform and to the ecological characteristics that control these functions. The HGM Approach is based on three fundamental factors that influence how wetlands function: 1) position of the wetland in the landscape (geomorphic setting); 2) water source (hydrology); 3) the flow and fluctuation of the water once in the wetland (hydrodynamics).

Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service 1979. Relies largely on vegetative cover because the type of plant cover (or the lack of it) is the kind of information that can be reliably interpreted from aerial photographs, which allows this classification system to meet one of its major goals - providing the basis for tracking changes in the surface area of wetlands over time through the National Wetland Inventory.

Methods for Evaluation Riparian Habitats with Applications to Management. U.S. Forest Service General Technical Report INT-221 1987.

Stream Corridor Restoration – Principles, Processes, and Practices. GPO Item No. 0120-A Federal Interagency Stream Restoration Working Group 1998. This document, the result of a cooperative effort among fifteen Federal agencies and partners to produce a common reference on stream corridor restoration, encapsulates the rapidly expanding body of knowledge related to this subject.

Applied River Morphology. *Dave Rosgen, Wildland Hydrology.* Presentation of techniques including: fundamental principles of river behavior; a hierarchical stream inventory; a classification of natural rivers with illustrations, data summaries, and photographs depicting major stream types. Field techniques and forms for: stream classification reference reach; bank erosion prediction; fish habitat structure evaluation; sediment relations; hydraulics; channel stability evaluations. Chapter titles include: new challenges; fundamental principles of river systems; stream classification; geomorphic characterization; morphological description; assessment of stream condition and departures from its potential; field data verification; applications.

BLM Riparian Area Management Series: Proper Functioning Condition (PFC).
A methodology for assessing the physical functioning of riparian and wetland areas. The term PFC is used to describe both the assessment process, and a defined, on-the-ground condition of a riparian-wetland area. In either case, PFC defines a minimum or starting point.

- Management Techniques in Riparian Areas TR 1737-6 1992
- Procedures for Ecological Site Inventory-with Special References to Riparian-Wetland Sites TR 1737-7 1992
- Greenline Riparian-Wetland Monitoring TR 1737-8 1993
- Process for Assessing Proper Functioning Condition TR 1737-9 1993
- Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas
- TR 1737-11 1994
- The Use of Aerial Photography to Manage Riparian-Wetland Areas TR 1737-10 1994
- Using Aerial Photographs to Assess Proper Functioning Condition on Riparian-Wetland Areas TR 1737-12 1996
- Observing Physical and Biological Change Through Historical Photographs TR 1737-13 1996
- Grazing Management for Riparian-Wetland Areas TR 1737-14 1997

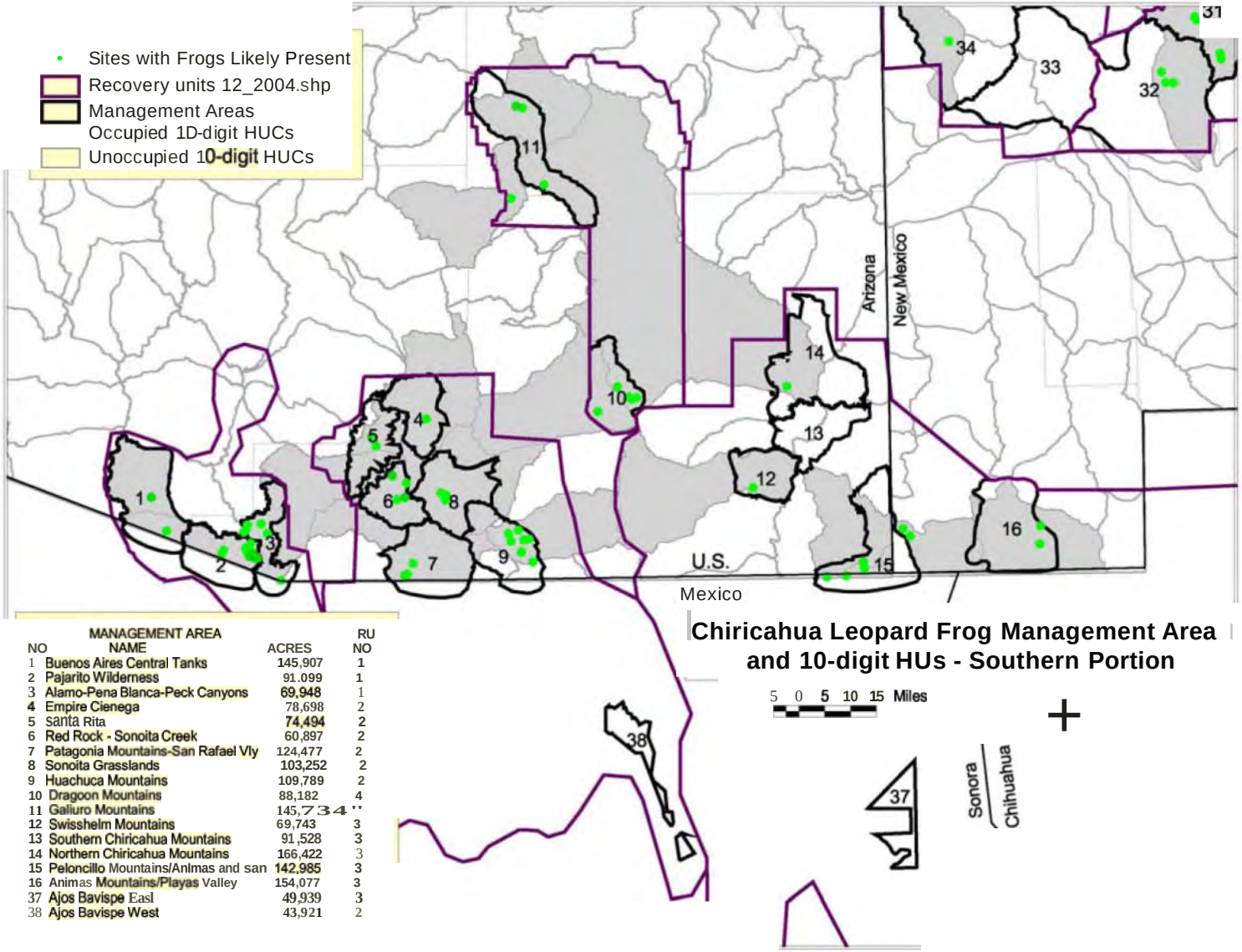
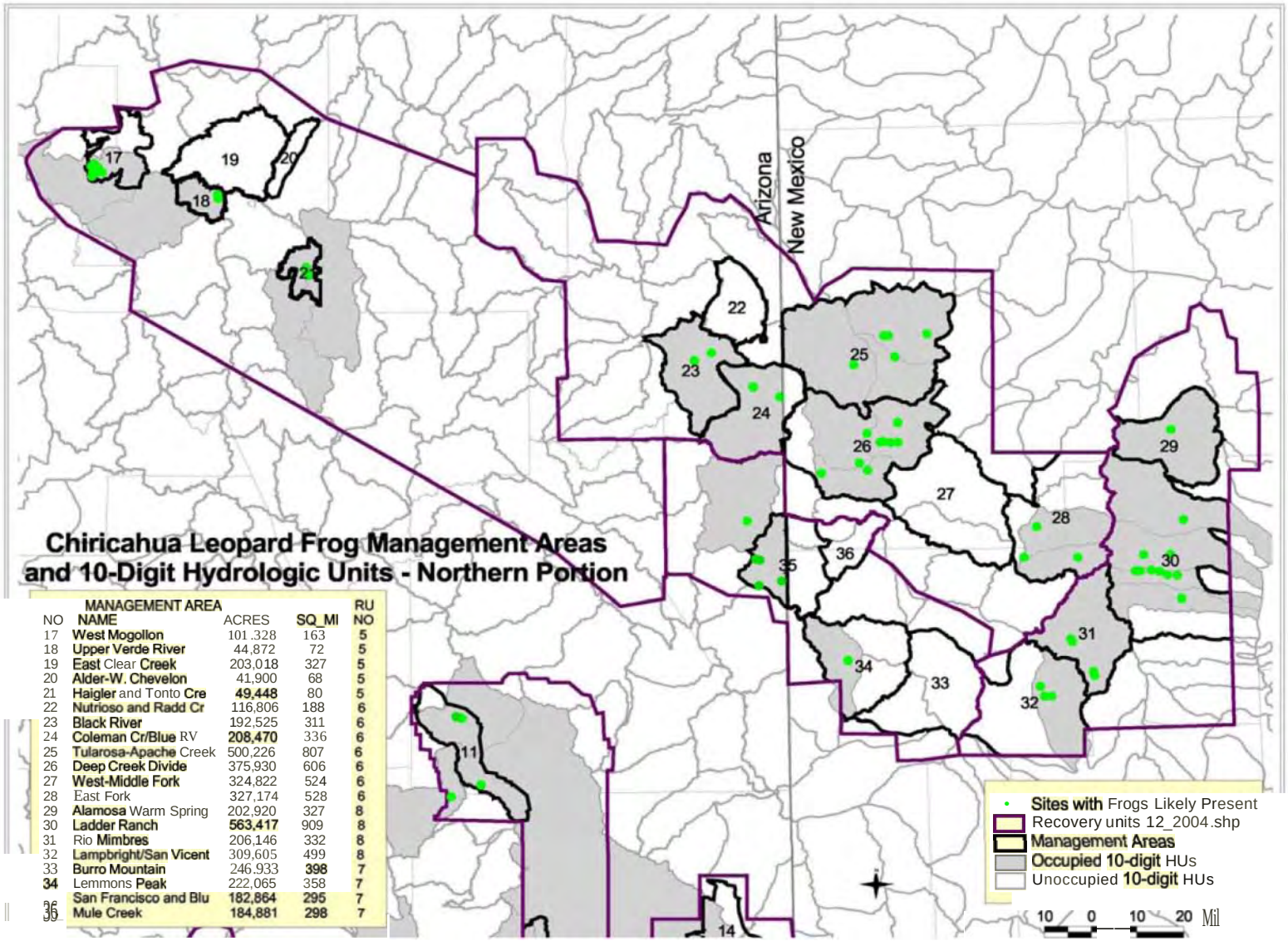


Figure H1: MAs, 10-digit HUs, and likely present frog localities – Southern portion.



NO	MANAGEMENT AREA NAME	ACRES	SQ_MI	RU NO
17	West Mogollon	101.328	163	5
18	Upper Verde River	44,872	72	5
19	East Clear Creek	203,018	327	5
20	Alder-W. Chevelon	41,900	68	5
21	Haigler and Tonto Cre	49,448	80	5
22	Nutrioso and Radd Cr	116,806	188	6
23	Black River	192,525	311	6
24	Coleman Cr/Blue RV	208,470	336	6
25	Tularosa-Apache Creek	500,226	807	6
26	Deep Creek Divide	375,930	606	6
27	West-Middle Fork	324,822	524	6
28	East Fork	327,174	528	6
29	Alamosa Warm Spring	202,920	327	8
30	Ladder Ranch	563,417	909	8
31	Rio Mimbres	206,146	332	8
32	Lampbright/San Vicent	309,605	499	8
33	Burro Mountain	246.933	398	7
34	Lemmons Peak	222,065	358	7
35	San Francisco and Blu	182,864	295	7
36	Mule Creek	184,881	298	7

Figure H2: MAs, 10-digit HUs, and likely present frog localities – Northern portion.

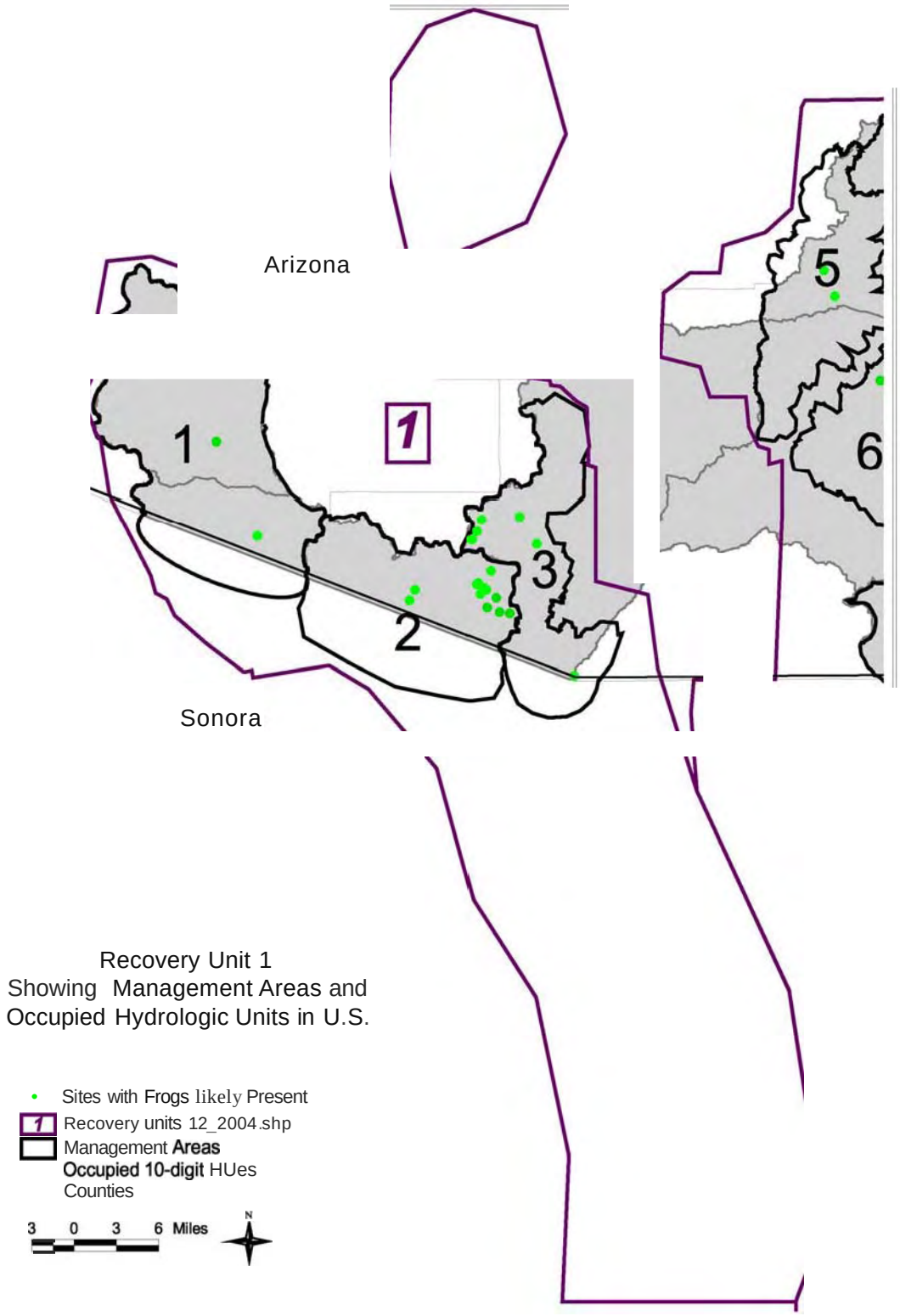
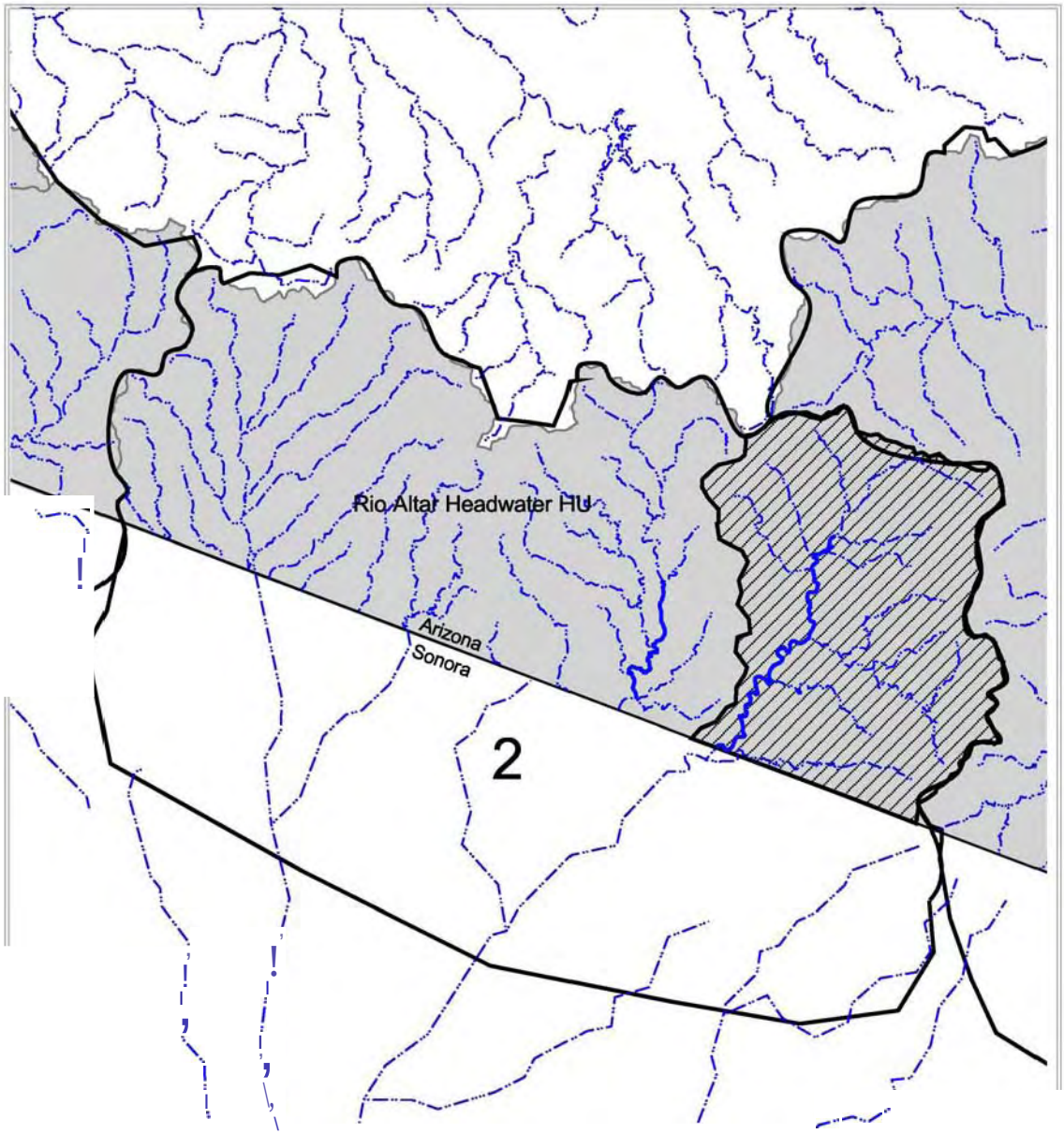


Figure H3, Map 1: RU 1 with MAs, HUs, and likely present sites.



Management Area 2 Showing 10-digit HU and Sycamore Canyon Watershed in U.S.

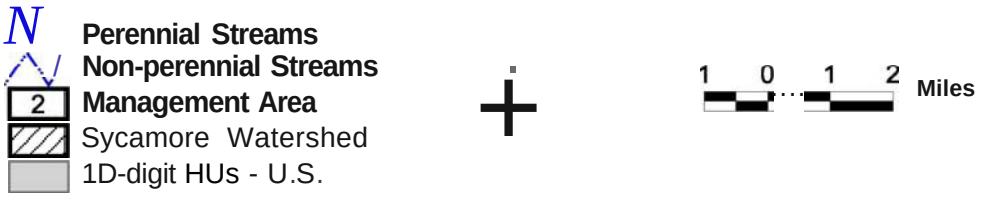


Figure H3, Map 2: RU 2 with MAs, HUs, and likely present sites.

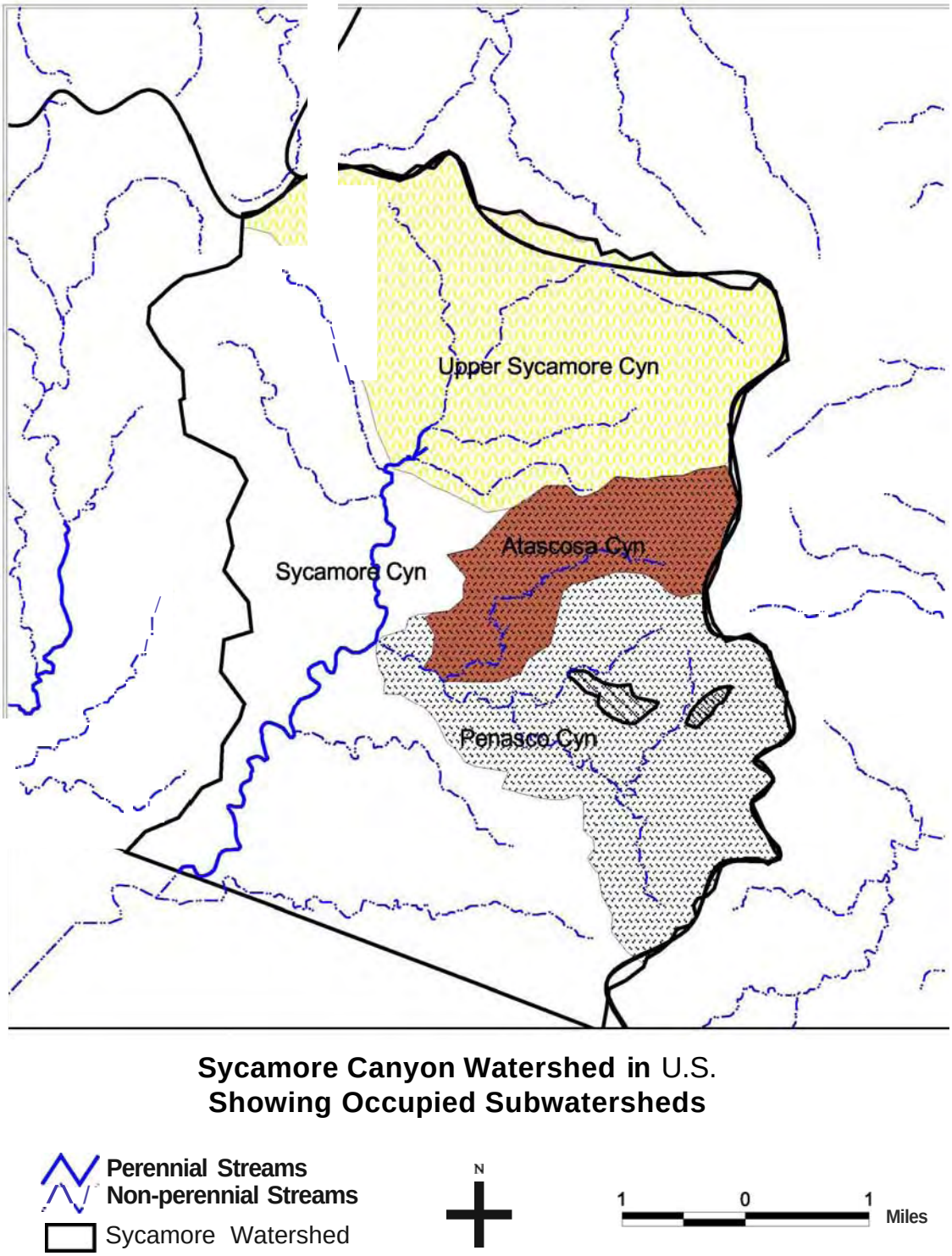


Figure H3, Map 3: Sycamore Canyon watershed, RU 1.

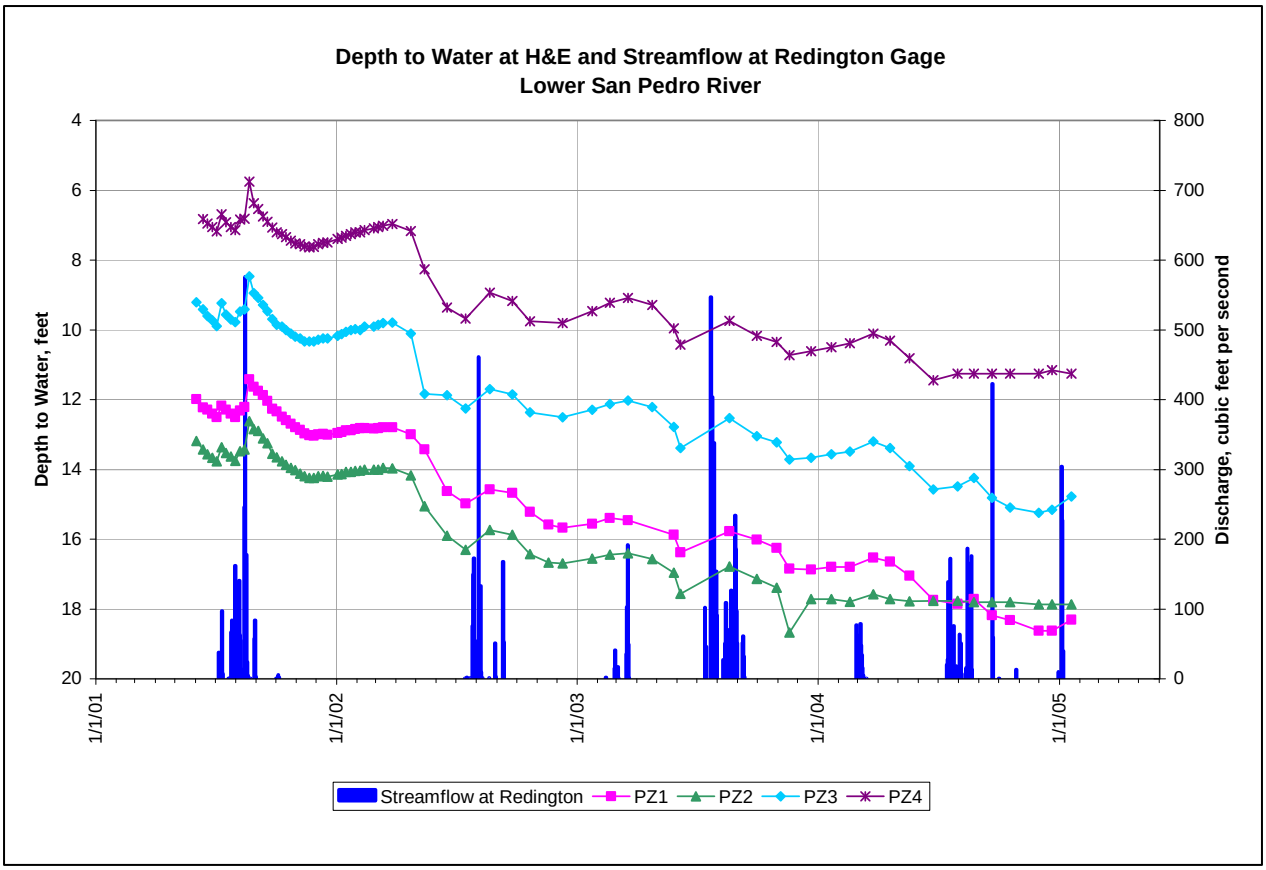


Figure H4. Rapid water level rise is observed beneath an ephemeral reach of the San Pedro River following flow events in the river. However, due to drought over the past years, the overall water level trend has been down, despite retirement of irrigated agriculture in this reach of the river.

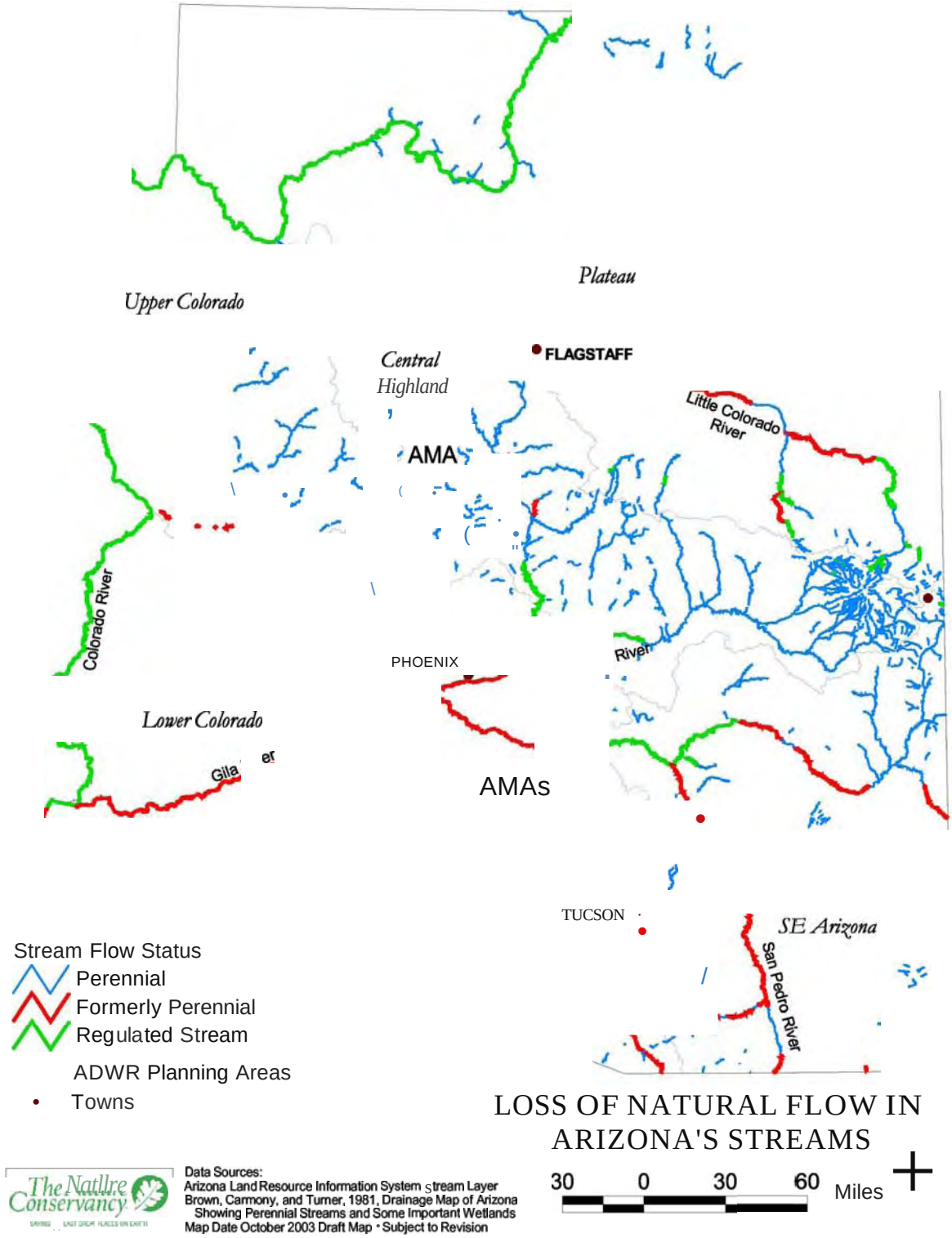


Figure H5: Loss of natural flow in Arizona's streams.

APPENDIX I

Recommended Conservation Measures for Projects Affecting Frogs

Conservation measures should, to the extent practicable, minimize effects of proposed projects on the Chiricahua leopard frog and its habitat. In order of preference, conservation should avoid, minimize, rectify, reduce, and/or compensate for the impacts of a project. The objective of conservation should be, within MAs, no net loss of frog suitable habitat quantity and quality, and maintenance or enhancement of movement corridors among populations and future population establishment/reestablishment sites. To the extent possible, adverse effects to extant populations of frogs should be avoided. The following conservation measures should be incorporated into all projects that may affect suitable frog habitats, sites selected for habitat restoration or creation, and movement corridors among sites within MAs. The measures may be modified as necessary to conform to the nature of the project or type of disturbance. Project conservation should also include measures for reducing the likelihood of disease transmission (see Appendix G). In regard to section 7 consultations, if these measures are added to project proposals, they will reduce effects of proposed actions and increase the likelihood that USFWS will be able to concur that a project may affect, but is not likely to adversely affect, the Chiricahua leopard frog; and in formal consultation, that a project is not likely to jeopardize the species. However, each project is different, and adherence to these conservation recommendations does not guarantee any conclusion or outcome in the section 7 process.

LIVESTOCK GRAZING AND MANAGEMENT

As discussed in “Reasons for Listing/Threats” in the body of the Recovery Plan, livestock grazing and management can have both positive and negative effects on Chiricahua leopard frogs and their habitats. Negative effects can include deterioration of watersheds, erosion and/or siltation of stream courses, elimination of undercut banks that provide cover for frogs, loss of wetland and riparian vegetation and backwater pools, spread of disease and non-native predators, degradation of water quality in ponds and livestock tanks, reduced water quantity in ponds and tanks due to water consumption by livestock, and trampling of egg masses, as well as larval, juvenile, and adult frogs. Positive effects can include construction and maintenance of livestock waters that provide habitat for Chiricahua leopard frogs. Livestock can also be used to open up aquatic habitat that in the absence of grazing may become overgrown, excluding or reducing habitat for frogs. Ranchers can also serve as eyes and ears to record and report frog die-offs, illegal activities, changes in habitat, and other factors that may affect recovery. Generally, under good ranch management, minor losses of frogs and some temporary deterioration of habitats as a result of grazing activities are not likely to result in extirpation of populations, and can be tolerated, although consideration may be given to finding ways to minimize these effects. Livestock grazing that does not compromise habitat suitability is compatible with healthy populations of Chiricahua leopard frogs. In northern Arizona and west-central New Mexico, elk can cause effects to frogs and habitats similar to cattle. The following are general guidelines for livestock (or elk) grazing practices in Chiricahua leopard frog habitat. Additional ideas can be found in Appendix A:

1. Manage livestock grazing in the watersheds of extant populations and habitat restoration/creation sites for improvement to, or maintenance of, satisfactory watershed conditions. In the case of degraded watersheds, several grazing strategies and guidelines may be considered to minimize impacts to the frog. Strategies that should be analyzed include riparian area exclusion, rest-rotation and deferred utilization, varied livestock types (e.g., change from cow-calf operation to steers or breeds which utilize dry habitats), and/or lowered stocking rates or smaller breeds for lighter utilization levels to limit forage removal. Strategies may include site-specific actions, such as: fencing or creation of pastures, relocation of water and salting sites away from wetlands, maintenance of stream bank stability (e.g., no more than 10 percent of natural stream bank stability altered by livestock trampling, chiseling, and sloughing), management of upland herbaceous vegetation for conservative utilization rates, and monitoring of utilization and subsequent habitat suitability for frogs. While implementing changes in livestock management to affect long-term watershed improvement, installation of control structures may be warranted for emergency control of headcuts that threaten frog habitats. Such management may not be necessary for some sites that are not affected, or only minimally affected by watershed condition, such as mine adits and some other artificial ponds. Implementation of grazing guidelines is of particular importance in MAs, especially where grazing impacts are adversely affecting extant populations of frogs or recovery sites.

2. When livestock tanks are newly constructed or reconstructed, consider how that tank may serve as a stepping stone for non-native species to move across the landscape and negatively affect leopard frog recovery. Careful placement of tanks and regulating public access may be necessary to ensure they do not become reservoirs of non-native predators. Also consider if these tanks can serve as habitat restoration/creation sites for future establishment or reestablishment of frog populations. Converting stock tanks to troughs or elevated tanks in which water is supplied by a pipeline, windmill, or solar pump should be considered if the site is expected to be colonized by non-native predators, but should be discouraged if it could serve as a habitat for Chiricahua leopard frogs.

3. Minimize livestock trampling and loss of bankline cover while still providing some open bankline for frog basking and foraging. Generally, avoiding damage to egg masses, tadpoles, and frogs is likely to require either light use of stock ponds used by frogs, or a good knowledge of when eggs are being produced. Potential conservation measures include, but are not limited to, partial fencing of tanks or other habitats, and construction of trick tanks or double tanks, one of which could be fenced, while the other is left open for access by livestock. Effects of livestock at tanks and ponds could be avoided by installing drinkers fed from a well or even from the stock pond itself, and keeping the cattle out of some or all of the pond area. Permanent fencing and livestock exclusion from an entire pond or habitat is not recommended unless the site is not likely to become overgrown.

4. Enhance underwater cover and substrates for egg mass deposition by placing logs and branches in the water.

5. Prevent water quality degradation. Areas in which livestock congregate may experience high levels of nutrients due to urination and defecation by these animals. This has been identified as a problem at some sites (see “Reasons for Listing/Threats” in part 1 of the Plan). Measures

should be implemented to alleviate water quality degradation. Suggestions include limiting the extent of time that livestock are allowed to congregate in aquatic sites harboring Chiricahua leopard frogs. If a demonstrated threat to Chiricahua leopard frogs exists, corrals should be moved or should not be proposed if adjacent to frog habitats where water quality degradation is likely to occur.

6. In regard to maintenance of livestock tanks, please refer to the Appendix A, Participation Plan.

FIRE SUPPRESSION AND PRESCRIBED FIRE

Fire in the short term produces harmful effects that, for leopard frogs, come primarily in the forms of (1) potentially toxic or suffocating ash runoff, and (2) increased sedimentation from bare ground, causing pools to fill and habitat to become simplified. Depending on the sensitivity of a regional leopard frog population, fire that occurs or is planned could cause a catastrophic loss. Although prescribed fire and wildfire almost always have short-term adverse effects to frogs and their habitats, properly managed low-severity fire can reduce the likelihood of catastrophic fires and improve habitat conditions in the long term. In regard to fire suppression near or in the watersheds of MAs, the following measures should be implemented to the degree that they do not compromise human safety or result in loss of homes or other high value property. The current fire management guidelines used by USFS, BLM, and other land managers should be evaluated for compatibility with these recommendations.

1. An objective of fire suppression should be protection of Chiricahua leopard frogs and their habitats.

2. All personnel on the fire should be briefed about protecting the Chiricahua leopard frog and its habitat.

3. On wildfires, Resource Advisors should be designated to coordinate listed species and other resource concerns and serve as an advisor to the Incident Commander. Resource Advisors should monitor fire suppression activities to ensure that protective measures endorsed by the Incident Commander are implemented. The Resource Advisor should also perform other duties as necessary to ensure adverse effects to the Chiricahua leopard frog and its habitat are minimized. Resource Advisors should be on call 24 hours during the fire season.

4. Off-road vehicle activity should be kept to a minimum. Vehicles should be parked as close to roads as possible, and vehicles should use wide spots in roads to turn around. Whenever possible, local fire-fighting units should go off-road first because of their prior knowledge of the area.

5. To the degree possible, crew camps, equipment staging areas, and aircraft landing and refueling areas should be located away from Chiricahua leopard frog populations and sites selected for habitat restoration or creation. Whenever possible, these activities should be located in previously disturbed areas. Any temporary solid and sanitary waste facilities should be

located well away from frog habitats. If such activities are located in Chiricahua leopard frog habitats, measures should be taken to limit habitat disturbance and to locate sites in areas with minimal effects to the frog and its habitat (see measures for surface-disturbing construction projects, below).

6. Use of tracked vehicles should be restricted to activities that, in the judgment of the Incident Commander and in consultation with the Resource Advisor, might save a large area or important resources from fire.

7. Fire crews should, to the extent possible, obliterate vehicle tracks made during the fire where presence of tracks is likely to encourage off-road travel by recreationists.

8. No fire retardants or suppressants toxic to fish or amphibians should be used over habitats occupied by Chiricahua leopard frogs, tributary drainages, or on the watershed where these chemicals are likely to enter occupied frog habitats.

9. Water should not be drafted from stock tanks or other aquatic habitats if Chiricahua leopard frogs are present or likely to be present, of if the site is known to be chytrid-positive. If stock tanks are refilled after a fire, only sources of water known to be free of non-native predators and chytrids (such as well water) should be used as a source. Avoid water drops on Chiricahua leopard frog habitats unless the water is known to be free of non-natives and chytrids.

10. If fire burns in the watershed of an extant population of frogs and in the judgment of the Resource Advisor will result in significant ash or sediment flow into that habitat, measures such as construction of waterbars in firelines, etc. should be implemented to direct flow away from frog habitats. If ash and/or sediment flow is likely to occur despite these measures, frogs and tadpoles should be salvaged and held at a holding facility until toxic conditions abate or habitat can be restored. If possible, at least 20 frogs and/or 100 tadpoles should be salvaged. Salvage can often wait until the fire is controlled in the area of the habitat. Ash and sediment flow will not be a problem until significant rainfall occurs. Appendices C, E, and I provide guidance on establishing refugia, and care and transport of frogs. It is imperative that unwanted genetic mixing not occur, that the frogs are not brought into contact with exotic diseases during salvage or at the holding facility, and that any repatriations are done carefully to avoiding moving anything except the frogs (ie., unwanted snails, algae, fish, etc.) back to re-release sites.

11. Rehabilitation of the burned areas should be undertaken, including seeding, planting of native perennial species, etc. Watersheds of occupied habitat and sites selected for habitat restoration/creation should be rested from grazing for the first two summer growing seasons (July, August, and September) following the fire.

12. Recovery of vegetation should be monitored.

13. The effectiveness of suppression activities and these measures should be evaluated after a fire. Procedures should be revised as needed.

The following measures should be implemented during prescribed fire (including prescribed natural fire) events. If a prescribed fire escapes prescription, the measures above for fire suppression should also be implemented.

1. An objective of prescribed fire should be enhancement of Chiricahua leopard frog habitat, with a recognition that some short-term adverse effects may occur prior to habitat enhancement.

2. Measures 2, 4, 5, 7, 11, 12, and 13 from the fire suppression measures above should be implemented.

3. Only light burns should occur in the watersheds of occupied Chiricahua leopard frog habitats and sites selected for habitat restoration/creation. However, if higher intensity burns occur and biologists predict that ash or sediment may flow into frog habitats, measure 10 for fire suppression, above, should be implemented.

FLOOD CONTROL

Guidelines on flood-control measures should be developed and implemented on public lands. Guidelines could include actions such as: maintenance of appropriate levels of down woody material in riparian zones and within 500-feet of aquatic frog habitats; avoidance of seeding/revegetating treated areas with non-native species (including using mulch that may contain non-native seed species); contour felling of trees within or just outside riparian zones to help reduce runoff and sedimentation of streams; and monitoring to verify effectiveness of actions. Guidelines should address impacts of flood-control activities carried out upstream of Chiricahua leopard frog habitat.

SURFACE-DISTURBING CONSTRUCTION PROJECTS

To the extent possible, surface-disturbing projects should be located outside of occupied Chiricahua leopard frog habitat, habitat restoration/creation sites, and the immediate watersheds of such habitats. If a project must be located in habitats or in the immediate watershed of habitat, effort should be made to locate the project in a previously-disturbed area, in an area where habitat quality is poor, or where impacts to the frog and habitat will be minimized. A reconnaissance of the project site should be conducted prior to construction in order to assist in locating the project. Prior to project initiation, an individual from the lead action agency should be designated as the field-contact representative. The field-contact representative should have the authority to ensure compliance with protective measures for the Chiricahua leopard frog and will be the primary agency contact dealing with these measures. The field-contact representative should have the authority and responsibility to halt activities that are in violation of agreed-upon conservation measures.

All project work areas should be clearly flagged or similarly marked at the outer boundaries to define the limit of work activities. All construction and restoration workers should restrict their activities and vehicles to areas that have been flagged to eliminate adverse impacts to the

Chiricahua leopard frog and its habitat. All workers should be instructed that their activities are restricted to flagged and cleared areas.

Within Chiricahua leopard frog habitats, the area of disturbance of vegetation, soils, and water should be the minimum required for the project. If possible, specify a maximum disturbance allowable based on the specifics of the project. Project activities should be located out of wetted sites to the extent practicable. Locate equipment staging areas, borrow sites, and material stockpiles well away from occupied habitat and habitat restoration/creation sites. Clearing of vegetation and grading should be minimized. Wherever possible, rather than clearing vegetation and grading, equipment and vehicles should use existing surfaces or previously disturbed areas. Shrubs that cannot be avoided should be crushed rather than graded out of the way, if possible. Where grading is necessary, surface soils should be stockpiled and replaced following construction to facilitate habitat restoration. Soils should be stockpiled outside of riparian and wetland areas, and should not be placed upstream or upslope of such sites.

Existing roads should be used for travel and equipment storage whenever possible.

Where feasible and desirable, in the judgment of the field-contact representative, newly created access routes in the action area should be restricted by constructing barricades, erecting fences with locked gates at road intersections, and/or by posting signs. In these cases the project proponent should maintain, including monitoring, all control structures and facilities for the life of the project and until habitat restoration is completed.

Measures should be designed and implemented to ensure hazardous materials, including, but not limited to, pesticides, fuels, oil, and other chemicals are stored well away and not upstream of frog habitats. Use of such materials should not occur in frog habitats and only in such a way that these materials do not enter frog habitats. If use of such materials is necessary, only use those that have been approved for use in aquatic systems and that have known effects on amphibians where possible. Measures should be taken to avoid or minimize runoff into and sedimentation of frog habitats.

A biological monitor (may be the same person as the field-contact representative), approved by the action agency, should be present in each area of active surface disturbance occurring in occupied frog habitat or restoration/creation sites, or in the immediate watershed of such habitats. Monitors should remain onsite throughout the work day from initial clearing through habitat restoration. The monitor(s) should perform the following functions:
Develop and implement a worker education program. Wallet-cards summarizing this information may be provided to all construction and maintenance personnel. The education program should include the following aspects at a minimum:

- description, biology, and status of the Chiricahua leopard frog;
- protection measures designed to reduce impacts to the species and its habitat;
- function of flagging designating authorized work area; and
- reporting procedures to be used if a frog is encountered on project sites.

Ensure that all project-related activities are in compliance with these measures. The biological monitor alone, or working through the field-contact representative or other on-site personnel,

should have the authority and responsibility to halt activities that are in violation of agreed-upon conservation measures.

Monitor frog habitats in the action area periodically to ensure effects are minimized. In addition, all hazardous sites (e.g., open pipeline trenches, holes, or other deep excavations) should be inspected for the presence of frogs prior to backfilling.

Work with the project supervisor to take steps, as necessary, to avoid disturbance to Chiricahua leopard frogs and their habitat. For example, if stream crossings by trucks or other heavy equipment are required, have monitors check for egg masses, frogs, and tadpoles. If avoiding disturbance to a frog, egg mass, or tadpole is not possible, or if a frog is found trapped in an excavation, the affected animals should be captured and relocated, or held for release at a holding facility following cessation of project activities as designated by the field-contact representative in consultation with the permitting State agency and USFWS. Affected animals should not be held in captivity for more than one year, and should not be relocated more than one mile away from the point of capture unless otherwise designated by the field-contact representative in consultation with the permitting State agency and USFWS (appropriate Federal and State permits are needed for these activities).

Take measures as needed to minimize the risk of disease transmission associated with construction projects. If vehicles/equipment use will occur in more than one frog habitat, ensure that all equipment is clean and dry or disinfected before it moves to another habitat (if the presence/absence of the disease is well known in the area, these rules could be varied; see Appendix G for additional information).

Additional Measures for Road Construction, Reconstruction, or Maintenance

Although not documented for Chiricahua leopard frogs, mortality of other species of leopard frogs by vehicle traffic on roadways can be considerable (Carr and Fahrig 2001) and roads may serve as barriers to movement (deMaynadier 2000). Fencing and culverts have been used successfully to reduce mortality of leopard frogs on roads and to minimize barrier effects (U.S. Department of Transportation 2001, Linck 1998).

Construction or major improvement/reconstruction of roads within 0.3 mile of occupied frog habitats or habitats selected for habitat restoration or creation should include a frog barrier fence on each side of the road that is exposed to frog habitat. In cases where such barriers could isolate populations, culverts should be installed to facilitate movement of frogs under the road (see U.S. Department of Transportation 2001 and "PROJECTS WITH LONG-TERM EFFECTS" below for design of fencing and culverts). Roads farther than 0.3 mile from occupied frog habitats or habitats selected for habitat restoration or creation may also need to be equipped with barrier fencing and culverts if the road would act as a substantial barrier to movement of frogs among populations, or to colonization of suitable habitats. Barrier fences and culverts are conservation measures to be considered in addition to those described above under "Surface-Disturbing Construction Projects".

Engineer and maintain roadways to minimize erosion/watershed degradation in the vicinity of suitable habitat. Salting of roadways adjacent to frog habitats should be avoided, or if necessary runoff patterns should be altered to avoid saline runoff into habitats. Design roads (or fence them) to discourage OHV use, camping near habitats, and other recreational activities that may adversely affect the frogs or their habitats.

Additional Measures for Mining

1. Develop appropriate mining plans of operation and implement changes in other uses as needed to maintain/improve watershed health and restore/maintain wetlands to the extent possible.

2. Construct control structures to minimize erosion.

3. Employ conservation measures below in regard to hazardous materials and pesticides.

4. Gravel-mining operations. Develop management guidelines for those operations adversely affecting Chiricahua leopard frogs and their habitat. Management guidelines may include such measures as: removal of artificial pools that have been created by suction dredging and now harbor non-native aquatic species (or may in the future), bank stabilization, reduction and containment of sediments, reduction of highbanking, and removal of gravels and soils above the high water mark and on adjacent terraces.

5. Creation of un-mined buffers one mile up- and downstream of known frog populations will contribute to recovery by eliminating potential negative effects on frog reproduction and survival. Sediment loads should be monitored for mining activities conducted greater than one mile upstream to evaluate whether Chiricahua leopard frogs are negatively impacted. If so, minimization measures should be enacted to reduce degradation of water quality. Strict management or elimination of mining activities is recommended on all public lands in occupied watersheds where Chiricahua leopard frogs are threatened by such activities. Where elimination is infeasible due to valid claims, and where mining operations are already permitted under the State Surface Mining and Reclamation Act, guidelines should be implemented to avoid impacts.

6. Where acid mine drainage from current or historic mining activities may be affecting Chiricahua leopard frog populations, identify measures to reduce or eliminate the effects. Acid mine drainage is associated with the extraction of many metals. High acidity can have direct effects on the frog and their prey base, or indirect effects by interactions with other actual and potential contaminants. Activities that contribute to acidic drainage should be discouraged in the watersheds of Chiricahua leopard frog populations. Drainage from historic tailings or other sources may be cleaned up or the drainage diverted away from the frog habitats. Some elimination or reduction of contaminant exposure might be accomplished through zoning regulations. This may entail working with county planning departments and agricultural commission offices to define areas where certain activities are not permitted or certain chemicals are restricted.

Additional Measures for Logging/Thinning

1. Frogs at high elevation or cold water sites may benefit from opening a closed canopy around a pond, allowing for higher water temperatures. However, in general, buffers of undisturbed or lightly disturbed vegetation should be left around occupied habitat and sites selected for population establishment/reestablishment. Buffers should be wide enough and have minimal surface disturbance necessary to eliminate or nearly eliminate erosion or sedimentation into occupied frog habitats or sites selected for restoration/creation as a result of disturbance in logged/thinned areas.

2. Develop and implement timber harvest guidelines to reduce impacts to the Chiricahua leopard frog and its habitat. Guidelines for minimizing impacts associated with timber harvest activities should be developed for each timber region that contains MAs. Implementation of guidelines should be refined for individual sites within MAs (i.e., based on topography, watershed conditions).

3. Design and maintain logging roads in a manner that reduces impacts. Erosion control features should be established on skid trails and tractor roads immediately upon completion of yarding on them in wet weather conditions. Road surfaces should maintain a hard surface (e.g., rock hardness) during periods of road use. Roads should be designed with the minimum width necessary to support the proposed use, roads on steep slopes (greater than 50 percent) should be full-bench design, and spoils should be disposed on grounds that are less than 30 percent slope and remote from watercourses. New roads and those requiring reconstruction should be out-sloped with rolling lips. After logging is completed, close logging roads/routes in the vicinity of occupied habitat and sites selected for restoration/creation.

HAZARDOUS MATERIALS, INCLUDING PESTICIDES

1. Use and store hazardous materials well away from occupied frog habitats and project sites selected for restoration/creation. Such materials should be stored downslope or in another drainage from frog sites.

2. Develop and implement hazardous materials spill contingency planning and prevention. A model oil and hazardous materials spill contingency plan is available at http://ifwes.fws.gov/Contaminants/SpillPlan/.

3. Adhere to the USFWS's Region 2 Pesticide Use Guidelines for Chiricahua leopard frog (White 2004).

4. Identify point and non-point source pollution and develop guidelines to reduce impacts. Identification of pollution sources will provide the focus for implementation of appropriate guidelines and impact minimization measures. Identification of non-point sources should include wastewater discharges and areas in which use of agricultural or other chemicals are concentrated.

5. Decontaminate aquatic habitats that support the Chiricahua leopard frog and are known to be contaminated. If contaminated, but occupied frog sites are identified, these sites should be cleaned up and remediation implemented as necessary at each site. Chiricahua leopard frogs should be removed from the site while clean up occurs and either relocated or allowed to disperse back into ponds once water quality has been improved (see Appendix D regarding holding facilities, and Appendices F and G regarding captive care, transportation, release, and disease prevention protocols).

6. Stop contamination of frog habitats from the direct application of herbicides and pesticides by road crews (e.g., county departments). Materials known to be toxic to aquatic and riparian species are routinely applied for control of roadside weeds and other unwanted vegetation as well as mosquito control. This is particularly important where ditches, riparian areas, and springs occur at roadsides. Other means to achieve weed or mosquito control should be developed with management agencies.

7. Use habitat-based measures to prevent contamination of Chiricahua leopard frog habitat. Habitat-based recovery actions that prevent the movement of pesticides into the aquatic environment should be used to reach this goal. For example, well-vegetated riparian areas and/or vegetation buffers around natural and artificial ponds should be protected and/or enhanced near agricultural and rural areas to prevent aerial drift and overland flow of chemicals into wetlands. Intensive farming should be avoided within a 1,500-foot buffer from occupied wetlands.

RECREATIONAL DEVELOPMENTS, ACTIVITIES

Hiking, fishing, horseback riding, and backcountry camping occur over large areas of public lands such as National Forest, BLM, State, and regional park lands. Habitat impacts associated with use of trails and roads, use of developed recreational sites, and dispersed use include wetland vegetation trampling, soil compaction, sedimentation, bank destruction, dammed pools, vegetation clearing, introduction of contaminants, spread of disease, and introduction of non-native fishes and American bullfrogs. Impacts to the Chiricahua leopard frog may include direct loss of egg masses and tadpoles due to trampling and decreased suitability of aquatic habitats due to the proliferation of non-native predators, sedimentation of pools, vegetation clearing or trampling, and decreased water quality.

1. Reduce the impacts of trail and road use on Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites on public lands. Depending on site-specific needs, trails and roads may need to be rerouted to avoid stream crossings and rerouted a distance of at least 500 feet from such habitats. Where stream crossings are absolutely necessary, measures that ensure that crossings do not degrade frog habitat should be implemented. Vehicular activities should be excluded from riparian and other wetland areas unless adequate stream crossings exist to prevent sedimentation. Roads within 0.3 mile of known populations of the Chiricahua leopard frog should be closed annually, if feasible, from March through October to prevent the killing of subadult and adult frogs on roads. Alternatively, roads can be fenced and culverts installed to allow safe crossings by frogs (see “Additional Measures for Road Construction, Reconstruction,

or Maintenance" above). With each of these actions, care must be taken to avoid impacting other species.

Management plans should include conservation such as: (1) closure or reroutes of trails or trail segments that cause degradation of Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites, (2) development of trails and overlooks which provide the public opportunities to view unique resources without impacting those resources, (3) closure and relocation of campgrounds and other developments to areas that are within a 500-foot distance from Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites , (4) development of interpretive trails and signs to educate the public about sensitive resources and habitats, (5) restoration of aquatic and upland areas that have been heavily degraded by recreational activities, and (6) installation of space barriers installed as appropriate to protect sensitive habitat areas. Existing guidelines for road development, maintenance, drainage, and surfacing should be followed to decrease impacts to the Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites.

2. Minimize off-highway vehicle impacts. Develop management guidelines for off-road vehicle uses where recreational activities have resulted in sedimentation of streams and ponds and the degradation of upland habitats. Many areas in National Forests need management of off-road vehicle use in occupied watersheds to decrease impacts to the Chiricahua leopard frog and other sensitive species. Sediment monitoring guidelines, permanent or seasonal closures, and development and maintenance of siltation ponds are needed in these areas.

3. Reduce impacts on the Chiricahua leopard frog from developed recreational sites and dispersed recreational use on public lands. Developed sites, including day use areas and campgrounds, often attract congregations of people around water. Management plans for developed recreational sites on National Forest, State park, and regional park lands are needed and should minimize impacts to the frog.

MONITORING AND RESEARCH ACTIVITES

Adhere to disease prevention protocols in Appendix G. Proposed monitoring and research recommended in the Step-Down Narrative should be funded first.

PROJECTS WITH LONG-TERM EFFECTS

Sites of permanent or long-term (greater than one year) effects, where continuing activities are planned that pose a hazard to frogs, may be enclosed with barrier fencing to prevent frogs from wandering onto the project site where they may be impacted. Barrier fencing should consist of flashing or other solid barrier material at least 12 inches high and buried sufficiently to ensure gaps do not form under the barrier. Hardware cloth with a 0.25-inch mesh may also be used if the top is folded over and out, away from the project site, to prevent frogs from climbing over the barrier.

GROUNDWATER PUMPING, IMPOUNDMENTS, AND SURFACE WATER DIVERSIONS

To the extent possible, groundwater pumping, impoundments, and surface water diversions should not be authorized where such activity would adversely affect occupied Chiricahua leopard frog sites or project sites selected for restoration or creation, unless such activities are unavoidable. If unavoidable, the action agency or project proponent should take every reasonable measure to ensure effects are mitigated to the maximum extent practicable. Conservation measures will need to be tailored to each project, but may include:
Relocating the project to a site where effects are minimized
Minimizing the amount or duration of water pumped, diverted, or impounded
Providing replacement water to frog habitats to offset impacts
Temporarily relocating frogs if disturbance to hydrology is temporary
Replanting riparian and wetland vegetation if temporary impacts desiccate these plants

HABITAT BUFFERS

Protected habitat buffers may be desirable in some cases to isolate frog habitats from human activities that cause or are suspected of causing effects beyond the actual boundaries of the activity (e.g. urbanization, fishing lakes, etc). Buffers should be sufficient in size and or quality such that effects attenuate across the buffer. This will vary by project type and habitats available as a buffer (see “Additional Measures for Logging/Thinning” above). The buffer should be in place and protected as such as long as the project effects manifest. Incorporation of the dispersal abilities habits of the Chiricahua leopard frog, and influences of habitat type and gradient, should increase the understanding of appropriate buffers by site.

RESTORATION OF DISTURBED AREAS

A project-specific habitat restoration plan should be developed by the project proponent. The plan should consider and include as appropriate the following methods: expansion or enhancement of affected wetlands, seeding or planting of plant species native to the project area, control of non-native plants or animals (without pesticides), erosion control, or other measures, as appropriate. Generally, the restoration objective should be to return the disturbed area to pre-project conditions, or at a minimum, to result in no net loss of frog habitat quality or quantity. Restoration may also present opportunities for improving or creating habitat over baseline conditions. The project proponent should conduct periodic monitoring of the restored area. Restoration should include eliminating any hazards to frogs created by the project, such as hazardous materials, areas of erosion, and holes or trenches in which frogs might become entrapped. Disturbance of existing perennial shrubs during restoration should be minimized. If unavoidable, crushing shrubs is preferable to digging or pulling them out, because crushed plants may resprout from the root crown.

COMPENSATION

Compensation is the least preferred option to address the impacts of a project on the frog or its habitat, and should only be considered if efforts to avoid, minimize, rectify, or reduce the impacts of the project have been expended. Given that frogs occupy relatively small areas, most projects should be able to avoid contact. To ensure no net loss of habitat quality or quantity, we recommend action agencies charge compensation to project proponents if net residual effects still would occur after all reasonable on-site conservation measures have been applied. Projects may have beneficial effects (e.g. see livestock grazing and management, above) that could balance adverse effects. Compensation funds should be used to acquire, protect, or restore Chiricahua leopard frog habitat, or to carry out other high priority recovery actions.

DETERMINING WHETHER COMPENSATION IS NEEDED

To evaluate whether it is appropriate to collect compensation, the action agency should consider whether, after all on-site conservation measures have been applied, the project would still have a net adverse affect to: 1) quality or quantity of occupied frog habitats or restoration/creation sites, 2) Chiricahua leopard frogs, or 3) corridors for movement of frogs among existing populations and/or project sites selected for restoration/creation in MAs. If any such net adverse residual effects still remain, then compensation is desirable. However, a project proponent or action agency does not need to compensate if the same or a different project proponent or agency already paid compensation for a particular area. That is, compensation is only needed once for multiple disturbances to a particular area.

COMPENSATION DETERMINATION

Compensation basis

The goal of compensation is to prevent the net loss of Chiricahua leopard frog habitat quantity and quality in MAs, to maintain or enhance movement corridors among populations, and to make the net effect of a project neutral or positive. To achieve this goal, compensation should be based on the area of frog habitat degraded or lost, degradation or loss of movement corridors, growth inducing effects, and the duration of the effects. Compensation should be determined by the following formula:

$$\textbf{Area} = A\,(B + G + D + 1)$$

Area is the suitable frog habitat land area that must be purchased or restored/created to compensate for residual effects. Other variables are evaluated as follows:

A **Net area (acres or hectares) in a MA of occupied frog habitat or habitat in a selected restoration/creation sites that is degraded or lost** (including areas where adverse effects to habitat, frogs, or both occur) due to the project, after all on-site conservation measures have been applied. Frog habitats include wetlands and associated

riparian vegetation in which frogs may forage or disperse. Frog habitats may be degraded if corridors to other suitable habitats are disrupted or compromised.

B Barrier to movement within MAs:
The project will not block or impede movement among occupied and/or restoration/creation sites 0
The project will block or impede movement between two occupied and/or restoration/creation sites 0.5
The project will block or impede movement among three or more occupied and/or restoration/creation sites 1.0

G Growth inducing effects (the project facilitates other development, recreation, introduction of non-native predators or disease, or other activities that will, in the future, adversely affect frogs or their habitats in a MA):
The project will have no growth inducing effects 0
The project will have growth inducing effects 0.5

D Duration of effect:
The effects of the project are expected to be short term (< 10 years).....0
The effects of the project are expected to be long term (> 10 years).....0.5

Applying the compensation formula above will result in 1:1 to 3:1 compensation, depending on the nature of the residual effects, as defined above. Within MAs, action agencies or project proponents should purchase and donate suitable habitat, or promptly create or restore replacement habitat in the quantity defined by the compensation formula. Quality of habitat should be equal to or greater than that lost or degraded. Action agencies may require project proponents to pay a monetary equivalent (including administrative costs) that is required to purchase and/or restore the required habitat.

If effects of a project results in less than $200 of compensation, action agencies should charge project proponents $200 as compensation to cover administrative costs of processing and evaluating requests.

COMPENSATION FUND ACCOUNTS

Each of the action agencies should maintain an accounting of all compensation funds paid and collected. These accountings should be incorporated into the annual monitoring report for implementation of the recovery plan. One of the agencies should serve as a clearinghouse for all compensation funds and accounting data. Project proponents would pay that clearinghouse agency through the action agency that authorizes the project. The Stakeholders Subgroups should be consulted as to how the funds are expended.

APPENDIX J

Guidelines for Backyard Chiricahua Leopard Frog Refugia

Authors: Dennis Caldwell and Angel Rutherford

Size and location

The pond should be located within the elevational limits of the species of frog designed for and in close proximity to the frog's historical distribution to ensure adequate climatic ranges. The pond should be 300 gallons or larger, 30 gallons per adult frog, and no less than 10 square yards surface area. The pond should be located where runoff from rainwater will not run into the pond and overflow it. The pond should receive at least 3 hours of sun per day at all times of the year. Overhead trees that allow filtered sun are good, but will increase the amount of debris buildup in pond. Pond should be equipped with a mechanism for draining.

Contour

New ponds should be designed with a variety of gradients. The shoreline should have some sunny shallows and some steep edges that drop off quickly to the deepest parts of the pond. Deep areas should be at least 2 feet deep. At least 50 percent of the shoreline should be designed for easy escape of non-aquatic animals from the water to avoid drowning.

Substrate

New concrete ponds should be constructed with lime inhibitors to avoid high water pH levels. Bottom substrates should be at least 3 inches deep with a variety of areas of wash sand and pea gravel. Make sure sand and gravel is from a non-polluted source. A few larger rocks should be arranged on the bottom as cover for tadpoles and frogs. Make sure gravel and rocks are not limestone or mineral rich. New ponds should be seeded with a gallon of bottom substrate (muck) from the wetland where the frogs originated to introduce algae, beneficial micro fauna, and to speed up water stabilization and biological filtration effectiveness. It is very important to utilize a chytrid free source for all plants and substrate.

Filtration

A biological filter should be incorporated with an oil-less, sealed pond pump, plumbed with PVC plastic pipe or nontoxic flexible hose. For a small pond, pump size should be able to move at least 500 gallons per hour. The water intake needs to have a prefilter to keep small tadpoles from being sucked into pump. It is recommended that the pond have an automatic fill with a float valve to avoid accidental drying.

Cover

The interior of the pond should be heavily planted with filtering/oxygenating plants like Coon's tail (*Ceratophyllum demersum*). At least 50 percent of the interior perimeter of the pond should

be planted with bushy native aquatic vegetation. Good native aquatic cover plants, are horsetail (*Equisetum laevigatum*), common cattail (*Typha latifolia*), common threesquare bullrush (*Schoenoplectus pungens*), devils beggarticks (*Bidens frondosa*), American brooklime (*Veronica serpyllifolia*), and pennywort (*Hydrocotyle umbellata*). Duckweed (*Lemna* spp.) should be avoided because it becomes problematic with pumps and filters. If possible, plants should be acquired from the wetland the frogs came from. Permission must first be obtained from the land manager of the plant removal site. If this is not possible, as a last resort, large selections of native plants are available from Hydra Aquatic, Inc. at hyraaquatic.com. Beware that these plants might harbor unwanted microorganisms and diseases. Never acquire plants from ponds that have been exposed to American bullfrogs. Bullfrogs are known carriers of the frog disease chytridiomycosis.

Keep a few basking sites along the sunny edges of the pond clear of vegetation so frogs have basking sites where they can sun. The outside perimeter should have at least 50 percent dense cover. Good non-aquatic perimeter cover plants are deer grass (*Muhlenbergia rigens*), hummingbird trumpet (*Zauschneria* spp.), or any other dense plant. Large rocks will add to cover variety and hold heat during cold weather.

Other animals

American bullfrogs and crayfish must not be introduced to the pond. If either species is likely to be in the area, measures should be taken to keep them out. This could be a barrier fence or wall. Most fish are not compatible with leopard frogs. Some native fish are compatible and can be acquired through your State Game and Fish Department. Cats and dogs should be watched closely in the vicinity of the pond. Stray cats should be discouraged. If wild skunks and raccoons are a problem, a thorny bramble of twigs surrounding the pool might help keep them away. Several species of birds can be problematic near frog ponds, especially herons and grackles. These birds are able to do significant damage to a small frog population and should be discouraged from your pond. Bird netting can be suspended over the pond to keep birds away when tadpoles are metamorphosing into vulnerable froglets. Netting can entangle frogs as well as other wildlife and should be used only when needed. Pile small branches and twigs in shallows and around the perimeter of the pond to discourage herons.

Mosquito control

Mosquitoes generally do not breed in ponds with moving water; however, if the pond is in an urban setting in close proximity to neighbors, mosquito control will be mandatory. The best choice is the native Gila topminnow. Your State Game and Fish Department should be contacted for native fish stock. The invasive mosquito fish (*Gambusia affinis*) must never be introduced into a leopard frog refugium; mosquito fish have been released into the wild throughout Arizona and have decimated populations of native fish and will readily eat hatching leopard frog tadpoles. Never take native fish from the wild without first getting permission from your State Game and Fish Department.

During the stabilization process, while starting up a new pond, BT Mosquito dunks (*Bacillus thuringiensis israeliensis*) can be used to eliminate mosquito larva from the pond until the pH is stable enough to introduce fish.

Chemical Additives

Chemical additives like algae removers, water clarifiers, and salts should be avoided and only administered on advice by a knowledgeable amphibian veterinarian. Pesticides should never be used near amphibian refugia.

Maintenance

In early winter, when egg masses are all hatched, thin emergent and perimeter vegetation to allow additional sunlight to reach basking sites. Remove excessive sediment buildup from bottom of the pond, making sure not to disturb sandy substrates. Always perform a partial water change after removing sediment. To perform a partial water change, you must change out a portion of the water by draining the pond down 10 inches, then refill the pond to the normal level. Through evaporation, salts build up in the pond; partial water changes should be performed several times a year. Never change out more than a quarter of the water in the pond and be extra careful when egg masses are present.

Algal Cycles

Ponds go through seasonal cycles of algal blooms. This is normal in any healthy pond and should not be discouraged. Frog larvae feed on algae and use it as cover. The natural stabilization process of a new pond involves algal blooms soon followed by the algae dying back and the water turning clear again. This cycle repeats several times the first year especially during the spring and fall as sunlight and temperatures are changing. During severe algal blooms, reduced oxygen levels in the pond might threaten fish. If necessary, a partial water change and/or increased water circulation will increase oxygen levels.

Rainy season frog dispersal

During summer rainy weather, many of the frogs will disperse from the pond. If the frogs need to be contained, a frog-proof perimeter fence will need to be installed.

Cannibalism

Big leopard frogs will eat small frogs. If frogs from your refugium are to be used to augment wild populations, late term larvae and froglets should be removed from the pond and held in a separate enclosure, safe from larger frogs.

APPENDIX K

Glossary

Adaptive Management: An interactive process whereby management of species populations and habitat is initiated, evaluated, and refined based on monitoring and research results.

Amplexus: The sexual clasp, in which a male frog assumes a piggy-back position, with his forelimbs encircling the female's body. In Chiricahua leopard frogs, amplexus is axillary or pectoral, in which the male's forelimbs encircle the female's chest just behind her forelimbs.

Augmentation: Intentional release of individuals into an area occupied by that species.

Conservation: From Section 3(3) of the ESA: The terms "conserve," "conserving," and "conservation" mean to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided under this Act are no longer necessary. Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transportation.

Conservation Action: A conservation action is a management action that, when implemented, will partially or wholly achieve stated objectives for covered species or land cover types.

Contaminants: Any undesirable physical, chemical, biological, or radiological substance present in water as a result of human activities.

Deme: A group of closely-related individuals. A deme may be a metapopulation, or groups of metapopulations or populations in a geographic area, such as a mountain range or river drainage.

Emergent: In flooded or ponded areas, rooted, herbaceous vegetation with parts of the shoot both below and above water, including cattail and bulrush.

Enzootic: Refers to a disease that is constantly present in an animal population, but usually only affects a small number of animals at any one time

Establishment: Intentional release of frogs to establish a population at a previously unoccupied site.

Extant: Currently existing, or not extinct. As in "extant" populations of frogs that are still in existence.

Habitat: The specific places where the environmental conditions (i.e. physical and biological conditions) are present that are required to support occupancy by individuals or populations of Chiricahua leopard frogs. Habitat may be occupied (individuals or population of the species are,

or have recently been, present) or unoccupied (see also “unoccupied habitat”, “potential habitat”, and “suitable habitat”).

Habitat Conservation Plan: Part of the application package for a 10a1B permit from the USFWS for incidental take of a listed species by a non-Federal entity. An HCP is a document that describes how agencies or landowners will manage their activities to reduce effects on vulnerable species. An HCP discusses the applicant's proposed activities and describes the steps that will be taken to avoid, minimize, or mitigate the incidental take of species covered by the plan.

Habitat Quality: Habitat quality refers to the ability of the environment to provide conditions that support individual and population persistence. High quality habitat includes all elements needed for relict leopard frogs to complete their life cycle. Low quality habitat would include only the minimal elements that support occurrence of relict leopard frogs.

Habitat Quantity: Habitat quantity refers to the area of the environment that provides conditions that produce or could produce occupancy of a given organism.

Historical Range: Those geographic areas inhabited at the time of modern exploration and settlement, as verified by museum voucher(s) or documented in the published literature.

Holding facility: Holding facilities will most likely be captive facilities at zoos, museums, backyard ponds, or other managed aquatic sites that may or may not be within a RU. However, holding facilities could also be actively-managed aquatic sites within a MA or RU. These facilities would be activated during drought, after fires in the watershed, or other disasters that threaten populations. Frogs may need to be temporarily captured and held in these holding facilities until ponds refill after drought, or other threats abate or are corrected (see recovery action 1.2.14).

Immediate watershed: Watersheds (typically USGS 10-digit Hydrologic Units) that surround extant populations and potential recovery sites. The term is used in reference to project areas that may impact extant populations or recovery sites.

Introduction: Release of individuals into an area not formerly occupied by that species

Inventory: The process of conducting surveys to determine total distribution and number of frogs.

Isolated Population: An isolated population is one that is beyond the reasonable dispersal distance from adjacent populations. Reasonable dispersal distance is generally a) within one mile overland, 2) within three miles along an ephemeral or intermittent drainage, 3) within five miles along a perennial stream (see page E-2 of appendix E), or some combination thereof. Potential dispersal barriers, such as ridgelines and waterfalls, should be considered when determining whether a population is isolated.

Loss of Habitat: Loss of habitat is a reduction in habitat quality or quantity that results from an adverse change in environmental conditions, such as cover, substrate, channel type, interacting species, river area, reservoir area, water quality, and groundwater depth.

Management area: A delineated region within a Chiricahua leopard frog RU in which recovery efforts will be focused; includes all known extant populations of frogs and areas with high potential for habitat restoration or creation, and establishment or re-establishment of frog populations.

Metapopulation: A system of local populations connected by dispersing individuals (or a set of local populations that interact via individuals moving among local populations, Hanski and Gilpin 1991). A local population is a set of individuals that interact with each other with a high degree of probability (Hanski and Gilpin 1991). Suitable habitat patches may support local populations; such patches without any individuals represent extinct local populations. Local populations are often disjunct, occupying relatively isolated suitable patches of habitat, but do not have to be so. Corridors are avenues of dispersal among local populations that possess habitat required for survival and feeding, but not necessarily suitable for reproduction or year-round use. Interactions among local populations (via the movement of individuals along corridors) establish a dynamic that can be characterized by the rates of local population extinction and recolonization, and that in turn, create a phenomenon of local population turnover. Metapopulations persist until all local populations are extinct (Hanski and Gilpin 1991). For the purposes of this recovery plan, we further define a metapopulation as consisting of at least four local populations that exhibit regular recruitment, three of which are extant most of the time. Local population will be arranged in geographical space in such a way that no local population will be greater than five miles from at least one other local population during some part of the year unless facilitated dispersal is planned. Metapopulations need to include at least one large, healthy subpopulation (e.g., at least 100 adults) in order to achieve an acceptable level of viability as a larger unit. If drought can be managed effectively so that small, lentic habitats have a good chance of persistence, overall metapopulation viability may be achievable with a smaller number of individuals per subpopulation (e.g., 40 – 50 adults). Most local populations should be robust (see definition below) and self-sustaining with minimal management (e.g. minimal or no augmentation, predator control, and habitat maintenance over a 25-year period).

Native Species: A species restricted to and only known to naturally occur within a specific geographic area.

Non-native Species: A species in a specific geographic area outside of its historical range.

Open Water: A flooded or ponded area that does not support rooted vegetation. Deep water (>1.8 m) or frequent, rapid fluctuation in water depth are usually the cause for the lack of vegetation.

Oviposition (sites): The act of egg-laying and/or the location where eggs are laid.

Population: A group of individuals of the same species inhabiting a given geographic area at the same time and among which mature individuals interbreed or are likely to interbreed. Ecological

interactions and genetic exchange are more likely among individuals within a population than with individuals in other populations of the same species.

Population persistence: A population of two or more frogs that includes at least one individual of each sex and exists for a given period of time. Note that a persisting population is not necessarily viable, but through reproduction it has the potential to exist beyond the life spans of the individuals in the population – see definition of "viable population".

Population stability: A population that shows stable or increasing trends and has not shown any significant decline from which it has not recovered during a 15 year period.

Potential Habitat: Habitat that is lacking one or more of habitat elements necessary to support a Chiricahua leopard frog population, but with proper management could develop into suitable habitat.

Project Site: Any project site in which recovery actions will be implemented; includes recovery sites targeted for maintaining metapopulations and isolated, but robust, populations of Chiricahua leopard frogs, refugia and holding facilities, aquatic habitat restoration project sites, upland project sites to be managed for watershed improvements or to facilitate dispersal of frogs, interpretive sites for public outreach, and other project sites. Project sites will usually, but not always be, located within MAs.

Range: The geographic area a species is known or believed to occupy.

Reestablishment: Intentional release of frogs to establish a population where frogs occurred in the past.

Refugia population: A captive or actively-managed wild population created to preserve local populations in MAs or RUs in which extirpation is likely in the near future. These refugia populations may also be desirable as a source of egg masses, tadpoles, and frogs for translocation to recovery sites, for augmentation, or to repopulate habitats after environmental disasters. Surplus frogs from these facilities may also be used for research purposes (see Recovery Action 7). Refugia populations may be located in wild or semi-wild managed aquatic habitats; or at zoos, museums, backyard ponds, fish hatcheries, or other similar facilities, which may or may not be located within the RU.

Recovery site: A site containing a metapopulation or isolated, but robust population, or sites where such populations would be established. Recovery sites that are metapopulations include likely dispersal corridors and aquatic sites, and upland habitats between populations through which frogs may disperse. Most or all recovery sites will be contained within MAs. These sites will often need active management to maintain or achieve habitat suitability, including habitat restoration and protection, and Chiricahua leopard frogs will need to be established or re-established at many recovery sites.

Repatriation: Intentional release of individuals into an area formerly occupied by that species.

Riparian: Vegetation or other resources associated with a river, spring system, or other aquatic site that are dependent on groundwater and floodwater controlled by the aquatic site. Common riparian vegetation community types in the historical range of the Chiricahua leopard frog, from high to low elevation, include blue spruce, southwestern maple/white fir, narrowleaf cottonwood, box elder/mixed deciduous, Arizona walnut, Arizona alder, Sycamore/walnut/ash, Fremont cottonwood/sycamore, Fremont cottonwood/willows, honey mesquite, salt cedar, salt cedar-honey mesquite, and marsh or cienega vegetation community types (Szaro 1989).

Robust population: A Chiricahua leopard frog population containing at least 60 adults and exhibiting a diverse age class distribution that is relatively stable over time. A population of 40-50 adults can also be "robust" if it resides in a drought-resistant habitat.

Safe Harbor Agreement: A voluntary agreement between USFWS and non-Federal landowners in which conservation benefits accrue to threatened or endangered species while providing the landowner assurances from additional ESA-related regulation. Once developed, the USFWS issues an enhancement of survival (10a1A) permit to the landowner for incidental take of the listed species above the baseline occurrence of the species on the enrolled properties at the time the agreement is signed.

Skeletochronology: A widely used histological technique to estimate age in amphibians and reptiles that exhibit cyclic patterns of bone growth. Cross-sections of the toes or other bones are histologically mounted and examined to count annual growth rings, similar to counting growth rings on a cross-section of a tree.

Succession: The change in the composition and structure of a biological community over time in the absence of major disturbance (e.g. fire, flood, land clearing by humans). For example, deep open water in a backwater may gradually fill over time with organic and inorganic material and become colonized by marsh species (e.g. cattail and bulrush). The marsh may eventually be succeeded by riparian forest of willows and cottonwoods. A major flood event could scour out the backwater site, returning it to an open water condition.

Suitable habitat: Habitat is suitable for Chiricahua leopard frogs if it falls within the range of habitat variation where the frog has been found. This range is described in the "Habitat Characteristics/Ecosystems" in part 1 and in the survey protocol in Appendix E.

SUL: Snout-urostyle length – the length of a frog measured from the anterior end the snout to the posterior end of the urostyle.

Translocation: Intentional release of individuals in an attempt to introduce or repatriate a species, or augment a population.

Unoccupied Habitat: Sites that support all of the constituent elements necessary for Chiricahua leopard frogs, but where surveys have determined the species is not currently present. The lack of individuals or populations in the habitat is assumed to be the result of reduced numbers or distribution of the species such that some habitat areas are unused. It is expect that these areas

would be used if species numbers or distribution were greater. See also definition of “habitat” and potential habitat.”

Viable Population: A viable population is one that has a probability of extinction of less than 10 percent in 100 years; also referred to as “long-term viability” in the recovery plan. This definition is consistent with the IUCN’s Red List definition for a species that is not “Vulnerable”.

APPENDIX L

Acronyms Used in This Document

ACEC Area of Critical Environmental Concern
AGFD Arizona Game and Fish Department
AZ Arizona
BANWR Buenos Aires National Wildlife Refuge
BLM Bureau of Land Management
C Centigrade
CEDES La Comisión de Ecología y Desarrollo Sustentable del Estado de Sonora
CBSG Conservation Breeding Specialist Group
CFR Code of Federal Regulations
CMA Cooperative Management Area
DOAC Didecyl ammonium chloride
DNA Deoxyribonucleic acid
DPS Distinct population segment
DVM Doctor of Veterinary Medicine
EPA Environmental Protection Agency
ESA Endangered Species Act
F Fahrenheit
FEV Frog erythrocutic virus
GPS Global positioning system
HCP Habitat conservation plan
HU Hydrologic unit
IMADES Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora
IIPAM Identification, Inventory, Acquisition, Protection and Management of Sensitive Habitats
IUCN International Union for Conservation of Nature and Natural Resources, or World Conservation Union
LC_{50} Concentration of a compound at which 50 percent of test organisms die in a given time period
LIP Landowner incentive program
MA Management area
MS 222 Tricaine methane sulfonate anesthesia
NAD North American Datum
NEPA National Environmental Policy Act
NM New Mexico
NMDGF New Mexico Department of Game and Fish
NRCS Natural Resource Conservation Service
NWR National Wildlife Refuge
OHV Off-highway vehicle
PARC Partners in Amphibian and Reptile Conservation
PCAV Polyhedral cytoplasmic amphibian virus
PCB Polychlorinated biphenyls
PCR Polymerase chain reaction
PDS Postmetamorphic death syndrome
pH Potential of Hydrogen; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution
PFC Proper functioning condition
Ppm Parts per million
PVA Population viability analysis
PVC Polyvinyl chloride
PVHA Population and habitat viability analysis
Quat128 A quaternary ammonia disinfectant
RMP Resource Management Plan
RU Recovery unit
SEMARNAP Mexico's Federal Secretaria del Medio Ambiente, Recursos Naturales y Pesca (Environment, Natural Resources and Fishing Secretary
SJV Sonoran Joint Venture
SUL Snout to urostyle length
TES Threatened and Endangered Species
TEV Tadpole edema virus
UGWA Upper Gila Watershed Alliance

USA United States of America
USAG United States Army Garrison
USDA United States Department of Agriculture
USFWS United States Fish and Wildlife Service
USGS United States Geological Survey
UTM Universal Transverse Mercator
UV Ultraviolet radiation
UV-A Ultraviolet-A radiation
UV-B Ultraviolet-B radiation
VES Visual encounter survey
WHIP Wildlife Habitat Incentives Program

APPENDIX M

Public and Peer Reviews of the Draft Recovery Plan and Responses

The Chiricahua leopard frog draft recovery plan was made available for public review for 60 days – from April 12 to June 12, 2006. Comments were solicited in an April 12 Federal Register notice; 263 letters to biologists, agencies, stakeholders, and other potentially interested parties; in news releases; and on the Fish and Wildlife Service's Arizona Ecological Service's Office website. Six comment letters were received. Herein we summarize comments from those letters and the resultant edits to the recovery plan.

PEER REVIEWS

We requested review of the plan by four peer reviewers (Dr. David Bradford, U.S. EPA, Landscape Ecology Branch, Las Vegas, Nevada; Dr. C. Kenneth Dodd, Jr., USGS/Florida Integrated Science Centers, Gainesville, Florida; Dr. Amy Lind, USDA Forest Service - Sierra Nevada Research Center, Davis, California, and Dr. Richard Zweifel, American Museum of Natural History (retired), Paradise, Arizona). We received comments from David Bradford and Richard Zweifel.

Richard Zweifel

A1: Zweifel noted redundancy in the plan, but added "Attempts to reduce redundancy very likely would be detrimental to other sections of the Plan, and in any event I have no specific suggestions to make along those lines".

Response: David Bradford also mentioned redundancy. Some of it is unavoidable – for instance discussion of threats, such as predators and chytridiomycosis, is needed in the Executive Summary, Part 1 – Reasons for Listing/Threats, to some degree in the recovery strategy and narrative outline, as well as in some appendices. That said, the bulk of the description of these threats should be presented in Part 1 – Reasons for Listing/Threats, and then referenced as needed elsewhere in the plan. The appendices provide greater detail on many topics, and in the body of the plan some text could be removed and referenced in those appendices instead. The Plan was examined for redundancy and, where appropriate, redundancy was reduced by cross-referencing or eliminating text where it was not needed.

A2: Page 10: The statement "No recent records (1995) to the present exist for the …Peloncillo Mountains…" conflicts with "A few populations persist …Peloncillo Mountains…" on page 63."

Response: The statements are technically correct, because the reference on page 10 refers only to the Arizona portion of the Peloncillo Mountains. The species still occurs in the New Mexico portion of the range. On page 10 after "Peloncillo Mountains", "(Chiricahua leopard frogs still occur in the New Mexico portion of this range)" was added.

A3: Pages 13-14: The last sentence on page 13, which extends onto page 14, includes a list of hypothetical predators. Zweifel notes "I forced a *T. cyrtopsis* (black-necked gartersnake) to disgorge two adult *Rana chiricahuensis* and a trout, and got a half-grown one from another."

Response: The following was added at the end of the sentence: "Zweifel (2006) observed predation of adult and juvenile Chiricahua leopard frogs by black-necked gartersnakes." Zweifel (2006 – his comment letter) was added to the Literature Cited section.

A4: On page 24, native fish associated with Chiricahua leopard frogs are listed. Zweifel notes that speckled dace (*Rhinichthys osculus*) occurred with Chiricahua leopard frogs historically in Cave Creek and East Turkey Creek in the Chiricahua Mountains. He also notes that both Chiricahua leopard frogs and an introduced trout were once abundant at the type locality for the frog at Herb Martyr Dam in the Chiricahua Mountains.

Response: Speckled dace was added to the list of species in the first full sentence on page 24. On page 22, last full paragraph, after the 2nd sentence the text was revised to read:

"Vredenburg (2004) demonstrated that introduced rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) were effective predators on mountain yellow-legged frog tadpoles (*Rana muscosa*), and that such predation was the most likely mechanism responsible for the decline of that frog. However, Zweifel (2006) observed both Chiricahua leopard frogs and trout (unknown species) in abundance at Herb Martyr Dam in the Chiricahua Mountains. Rosen (1996a) suggested…"

Vredenburg (2004) was added to the Literature Cited.

A5: Page 66, "opportunities for establishing populations at the Muleshoe Ranch…" Zweifel questions whether Chiricahua leopard frogs would be appropriate at this locale. He has observed only lowland leopard frogs.

Response: There is a sight record for Chiricahua leopard frog from upper Redfield Canyon on the Muleshoe Ranch in 1991 and there are numerous Chiricahua leopard frog localities from elsewhere in the Galiuro Mountains. However, most leopard frogs identified on the Muleshoe Ranch have been lowland leopard frogs. The last sentence in the first full paragraph on page 66 was revised to read as follows:

"…and opportunities for establishing populations at appropriate sites on the Muleshoe Ranch should be explored with The Nature Conservancy, BLM, and the Coronado National Forest."

A6: Wasn't the town of Playas taken over by the Federal Government for training soldiers in urban warfare? (See last full paragraph of page B-13)

Response: Yes, the town was purchased by New Mexico Tech in 2004 and is being used as a training site for counter-terrorism urban warfare by the Department of Homeland Security. The text on page 66 was revised to reflect this.

A7: Silver Creek stock tank, between Portal and Paradise in the Chiricahua Mountains, is potentially an excellent site to reestablish Chiricahua leopard frogs, if the cooperation of the property owner can be obtained. There may also be reestablishment potential at the Southwest Research Station (an historical locality) near Portal.

Response: On page 64, in the "Crucial Recovery Needs" for RU3, the following sentence was added to the 2nd paragraph, which becomes the 3rd to the last sentence:

"Discussions should be initiated with the owners of the Silver Creek stock tank and Southwest Research Station near Portal to explore opportunities for population reestablishment at these historical localities."

David Bradford

B1: Bradford is concerned about uncertainties involved with controlling two of the major threats – invasive predators and chytridiomycosis. He believes the cost estimates in the implementation schedule to address these problems are inadequate.

Response: We agree that costs are likely underestimated for dealing with these serious threats. In regard to controlling predators, we have some idea of the costs in relatively simple systems (e.g. ~$5,000 to treat a stock tank); however, it would take further analysis to determine how many such sites would need to be treated, and we do not fully understand the techniques or costs associated with control in larger systems. In response, the per year cost estimate for recovery task 1.2.9 (total of $100k, as written) was replaced with "TBD" (to be determined). The same rationale was used to revise recovery task 1.2.12 (replaced $ with TBD). Task 6.13, which would research and evaluate methods to control predators and competitors remained the same (total of $150k), as did 6.19, which would investigate methods to treat chytridiomycosis in wild frog populations (total of $85k over 5 years).

B2: Need definition for "isolated" in reference to isolated robust population (see recovery criterion 1).

Response: Added "isolated population" to the glossary. Defined as follows: An isolated population is one that is beyond the reasonable dispersal distance from adjacent populations. Reasonable dispersal distance is generally a) within one mile overland, 2) within three miles along an ephemeral or intermittent drainage, 3) within five miles along a perennial stream (see page E-2 of appendix E), or some combination thereof. Potential barriers, such as ridgelines and waterfalls, should be considered when determining whether a population is isolated.

B3: "The main difficulty in using the document is its size and the fact that a topic (e.g. role of invasive species in population declines or recovery) is addressed in many places. Cross-referencing was often helpful in this regard, and the use of appendices for the more detailed information was also useful."

Response: See response to A1.

B4: "Is there a reason why the implementation schedule (Part III) is not listed as a table in the Table of Contents?"

Response: Implementation Schedules typically are not referred to as tables in recovery plans (and was not referred to as such in the draft plan). It was not listed as a table in the Table of Contents.

B5: "In a few places in Part 1 there was some mixing and confusion between background material appropriate for Part 1 and speculation or management actions that seemed more appropriate for Part II (see minor comments below)." The minor comment to which Bradford refers is likely B9.

Response: In a few places in Part 1, we make reference to recovery or recovery actions that should be taken (see page 17 – middle of 2nd full paragraph; page 18, last paragraph; page 38 – discussion of agriculture; and page 49, last full paragraph). These sections were modified to present factual information pertaining to the biology, threats, and other material appropriate for Part 1; while discussions of recovery needs were removed.

B6: "P. v. & 149. My guess is that the total costs are an underestimate, especially since cost estimates for some items are listed as 'TBD'."

Response: The text makes it clear on page v. and 149 that these are minimum costs that do not include to-be-determined costs. However, we revised "Does not include TBD costs" at the bottom of page 149 to "These totals are minimum cost estimates that do not include TBD costs".

B7: Replace "Bradford 2002" with Bradford, D.F., J.R. Jaeger, and S.A. Shanahan. 2005. Distributional changes and population status of amphibians in the eastern Mojave Desert. Western North American Naturalist 65:462-472."

Response: Revised as suggested.

B8: In reference to page 9, lines 4 and 5, Bradford suggests providing sample sizes rather than "almost all perennial waters" and "All waters".

Response: The text was revised to provide numbers rather than qualitative descriptors, as suggested.

B9: Page 18, last paragraph – it is confusing because it shifts between discussing background material to recommendations for management.

Response: See response to comment B5.

B10: Page 22, paragraph 2, line 3: This argument would be strengthened by providing sample sizes for "All historical".
Response: The text was revised to provide number of sites that corresponds to "all historical".

B11: Page 22, paragraph 4, line 9: It is not clear whether "may prove harmful" is speculation or based on observation.

Response: Interactions between Chiricahua leopard frogs and mosquitofish have not been well studied. However, at Beatty's Guest Ranch in southern Arizona, a healthy population of Ramsey Canyon leopard frogs exists in the presence of mosquitofish, but tadpole densities appear lower than at some other sites. Revised to read " Mosquitofish and Chiricahua leopard frogs can coexist; however, in at least in some circumstances (especially at high abundance of mosquitofish and/or low habitat diversity), predation by mosquitofish may greatly reduce larval frog survival."

B12: page 28, paragraph 2, lines 3-4: Can a source (e.g. pers. comm., publication) be cited for the statement "Free-ranging healthy American bullfrogs with low-level chytridiomycosis infections have been found at Cienega Creek, Arizona."?

Response: This statement is from Bradley *et al.* (2002). The text was revised to include this citation.

B13: Page 40, last paragraph, lines 2-4: Not clear what constitutes relatively short viability in regard to the following statement:

"Because of the inherent dynamic nature of southwestern wetland and riparian habitats, coupled with the increased likelihood of extirpation characteristic of small populations, the viability of extant populations of the Chiricahua leopard frog is thought, in many cases, to be relatively short."

Response: Revised to read: "Southwestern riparian and aquatic systems are inherently dynamic due to seasonal and longer-term drought and wet periods, floods, and fire. Dynamic habitats combined with often small populations of adult frogs create circumstances in which population sizes vary greatly over time and populations are periodically extirpated."

B14: Page 60, paragraph 3. Spelling ""dentification".

Response: Corrected: "identification".

PUBLIC/AGENCY REVIEWS

U.S. Forest Service, Region 3, Albuquerque, NM

C1: "One concern is that the stakeholder subgroup approach was not consistent for all recovery units. We recommend the U.S. Fish and Wildlife Service assign this role to a FWS employee, contractor, or another Federal or state employee that would be accountable to and meet the expectations identified by the FWS."

Response: We assume the commenter refers to the Team Leader or Mediator position. The Stakeholder Subgroups should represent the views of regional stakeholders. As a result, in most cases it will not be appropriate for the FWS employee to serve as Team Leader or Mediator (an exception may be in the case of RUs that contain wildlife refuges). As a result, Stakeholder Team Leaders or Mediators could come from a variety of backgrounds. In the case of the three stakeholder groups, one was lead by U.S. Forest Service employees, while the other two were lead by Malpai Borderland Group representatives. The subgroups worked well, and we see no reason to limit those who can serve in leadership roles.

C2: "We suggest that wildland fire use and prescribed burns be encouraged, while noting that low intensity burns are desired in the vicinity of frog habitat. This allows the FS to restore National Forest System lands and ecosystems that are fire-adapted to be more resilient and resistant to large-scale, high intensity burns. Large-scale, high intensity burns are the type that results in the most devastating effects to frog populations."

Response: Recovery action 1.2.4 calls for restoration of natural fire regimes in the watersheds of extant populations of Chiricahua leopard frogs in MAs, including the use of prescribed fire, managed natural fire, and wildfire that will result in restoration of hydrologic function. Fuels management and wildfire suppression are noted as crucial recovery needs and/or wildfire is described as a crucial threat in RU 2 (page 62), RU 3 (page 64), RU 6 (page 68), RU 7 (page 70), and RU 8 (page 71); and the threat of catastrophic wildfire figured prominently in the threat assessments in Appendix B. The destructive nature of catastrophic fires is described on pages 38 and 39. Effects of, and measures to minimize, impacts of fire suppression and prescribed fire activities are described in Appendix I (pages I-3 to I-5) and recognize that habitats can be protected and can improve in the long-term through fire management, but revisions in the opening paragraph on page I-3 were made to better emphasize the benefits of fire-management activities. Inserted the following as the 3rd sentence in that paragraph: "Although prescribed fire and wildfire almost always have short-term adverse effects to frogs and their habitats, properly managed low-severity fire can reduce the likelihood of catastrophic fires and improve habitat conditions in the long term."

C3: The draft Recovery Plan states that suitable frog habitat exists in the Cibola National Forest. Habitat there is better described as "potential"; the metapopulation that includes the Alamosa Warm Springs probably did not include populations in the San Mateo Mountains because of a lack of suitable habitat.

Response: See response to C4.

C4: Little recovery opportunity exists in the Cibola National Forest; identification of recovery sites there is probably inappropriate because aquatic sites are not drought resistant, there is a lack of perennial water in the Magdalena Ranger District (which includes all portions of RU 8 on the Forest), no populations of Chiricahua leopard frogs have been found despite surveys at all potential habitats within 5 miles of the extant population at Alamosa Warm Springs, and stock tanks in the area do not hold water long enough to allow larval development.

Response: In the sentence in the last paragraph on page B-85 "The San Mateo Mountains...proximity to this locality and presence of suitable habitat." "Suitable" was replaced with "suitable or potential". We also inserted the following after that sentence: "Surveys for frogs on the Cibola National Forest at all potential habitats within five miles of the Alamosa Warm Springs population have been negative. There is a lack of perennial water and probably little recovery potential in this area of the Cibola National Forest."

C5: Recommend rewording the statement on page H-13 to better describe which activities "may need to be eliminated from occupied watersheds for a period of time, to provide frogs and their habitat the opportunity to recover from excessive stresses."

Response: Consistent with the first part of this paragraph, inserted "(e.g. livestock grazing, mining, recreation, timber harvest, water uses)" after "In some instances, certain activities" in the middle of page H-13.

C6: Page H-14: Clarify how delineation of MAs (Figures B1-8) provides direction on where habitat suitability and connectivity are considered important for recovery.

Response: The section to which the commenter refers also makes reference to "Crucial Recovery Needs" in the RU descriptions in the body of plan, and the more detailed RU descriptions in Appendix B. Together with the MAs, these sections describe areas that have the greatest potential for successful recovery. The value of MAs for recovery is described in the first paragraph on page 53. No revisions needed.

C7: Page H-14: Clarify which areas have been noted as being very important to the ecological function of adjacent sites that currently support the Chiricahua leopard frog.

Response: These specific areas are described to some degree in Appendix B and in the "Crucial Recovery Needs" (see these sections), and watersheds of extant populations of frogs (see recovery action 1.2.1 and Appendix H). Additional areas will be identified as recovery sites are identified and evaluated (see recovery actions 1.2.17.1, 2.1, and Appendix D). No revisions needed.

C8: Page I1, 3rd sentence: Insert "suitable" before "habitat".

Response: Revised as suggested.

C9: Page I-2: The Recovery Plan should identify where grazing impacts are adversely affecting extant populations of frogs or recovery sites.

Response: There is very little discussion in the Plan of specific sites impacted by grazing (however, see discussions in Appendix B, page 35, and "Crucial Recovery Needs" in the RU descriptions, pages 58-71). The purpose of Appendix I is not to identify specific sites where impacts may occur, but rather to provide a shopping list of recommended conservation measures that can be helpful to Forest biologists, range conservationists, ranchers, and others involved in

livestock management. Discussions of impacts at specific sites are more appropriately deferred to project-level section 7 consultations and other analyses. No revisions needed.

C10: Page I-5: The term "immediate watershed" should be defined.

Response: "Immediate watershed" is defined on page 58: "(typically USGS 10-digit Hydrologic Units) that surround extant populations and potential recovery sites". The following definition was added to the glossary:

Immediate watershed: Watersheds (typically USGS 10-digit Hydrologic Units) that surround extant populations and potential recovery sites. The term is used in reference to project areas that may impact extant populations or recovery sites.

C11: Pages I-6 and 7: Within Federal land management agencies, the field-contact representative (page I-6) or the biological monitor (page I-7) are not likely to have the authority to halt activities in violation of agreed upon conservation measures. That authority usually rests with the line officer or contracting officer.

Response: If a monitor or field contact representative detects project activities that are outside agreed upon conservation measures, that person should go through established channels so that those activities can be suspended pending review. In regard to biological monitors, we made the following revision to the 2nd sentence in the 2nd paragraph on page I-7: "The biological monitor alone, or working through the field-contact representative or other on-site personnel, should have the authority and responsibility to halt activities that are in violation of agreed upon conservation measures."

C12: Page 1-10, item #1, Recreational Developments, Activities: Should be reworded so it is clear that only trails and roads within or adjacent to occupied or suitable habitat be rerouted.

Response: In item #1, sentence 1, replaced "Chiricahua leopard frog habitat" with "Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites". In the 2nd sentence, replaced "wetland (i.e., springs, wet meadows, ponds, marshes) frog habitats" with "such habitats". In the 2nd paragraph of item #1, part (1), replaced "aquatic systems" with "Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites". In part (3) replaced "frogs habitats" with "Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites". In part (6), replaced "Chiricahua leopard frog habitats" with "Chiricahua leopard frog suitable or occupied habitats, or identified recovery sites".

C13: Page I-11, part (3): It is recommended that campgrounds or other developments within 500 feet or frog habitats be closed or relocated. Suggest that this be applied only to occupied or suitable habitat.

Response: Addressed in response to C12.

C14: The Cibola National Forest would like to be involved in the development of Watershed Use and Management Guidelines as identified in the recovery actions (1.2.1) and in the development of guidelines for logging/thinning in the Alamosa Warm Springs MA.

Response. The descriptive text for recovery action 1.2.1 makes it clear that the recovery plan, including Appendix H, is providing information for land managers or others to develop watershed use and management guidelines. The Southwestern Region's watershed, soil, and water conservation guidelines are cited as one of those sources of information. We expect that the Cibola National Forest would be the lead land manager developing any watershed and management guidelines for forest lands in the Alamosa Warm Springs MA. Similarly, Appendix I, page I-9 and elsewhere, only provide recommended conservation measures for logging or thinning projects, and do not prescribe to land managers the content of such measures. No revisions needed.

C15: page I-5, item #1 and 4: Need to portray the benefits of prescribed fire. Also, in item #4, the monsoon season is often the best time to burn because this is when fires naturally occur and high intensity fires are unlikely.

Response: See response to C2. In regard to fire in the uplands during the monsoon season, if it is wet enough for frogs to be moving across the landscape, it is probably too wet for a fire to carry. Item #4 was removed.

Arizona Game and Fish Department

D1: "In addition to recovery actions described in the Draft Plan, we urge the Service concurrently to develop conservation tools that provide assurances in conservation planning to private landowners and therefore contribute to successful recovery of Chiricahua leopard frogs."

Response: Appropriate conservation tools would include Safe Harbor Agreements, Habitat Conservation Plans and associated Incidental Take Permits, private and tribal lands agreements, recovery and enhancement of survival permits, and using our authorities to assist private landowners to accomplish recovery (e.g. our Partners for Fish and Wildlife Program). These tools are mentioned in recovery actions 2.3, 4.3, 5.2, 8.1, 8.2, 10.2, and 11.2, and are also described in "Previous and Ongoing Conservation Measures" in Part 1 and in Appendix A. Our recently completed Statewide Safe Harbor Agreement for the Chiricahua leopard frog, whereby AGFD holds a master permit and individual non-Federal landowners can sign on to the agreement through a Certificate of Inclusion (described on pages 48 and 49), provides an example of conservation tools. Given the coverage on this topic, no additional revisions are needed to address this comment.

D2: Page 56, Recovery Units third paragraph: "Change third sentence of paragraph from 'Hydrological units are used as MA boundaries because…' to 'Hydrological units and mountain ranges are used as MA boundaries because…"

Response: Revised as suggested.

D3: Page 57, Recovery Units, first partial paragraph. "Change last sentence of paragraph to 'If other populations are found in the future outside an established MA, the habitats of those populations will be included in the appropriate MA."

Response: It is possible that populations disjunct from established MAs could be found, and that no "appropriate" or adjacent MA may be available to which the new population could be attached. In those cases, a new MA may be warranted. Revised as follows:

"If other populations are found in the future outside an established MA, an adjacent MA will be extended to include the habitats of those populations, or a new MA should be established based on those populations."

D4: Page 58, Recovery Unit 1: "Add Tumacacori Mountains to the description."

Response: In the 2nd sentence of the "Description" on page 58, replaced "Pajarito-Atascosa Mountains" with "Tumacacori-Pajarito-Atascosa Mountains".

D5: Page 77, Narrative Outline for Recovery Actions 1.2.6: "Change 'Part VI, Actions Available for…' to 'Part II, Actions Available for…"

Response: Revised as suggested.

D6: Page 88, Narrative Outline for Recovery Actions 6.19, second sentence: Insert 'to' before 'clear".

Response: Revised as suggested.

D7: Page A-1, Appendix A, third paragraph, second sentence: Delete 'for' after 'recovery plan contains…".

Response: Revised as suggested.

D8: Page I-14, Appendix I: "Compensation is misspelled in the section heading named "Comppensation Fund Accounts"

Response: Corrected spelling.

D9: "Add definition of 'persistence' to the Glossary (Appendix K)."

Response: "Persistence", particularly as it is used in regard to long term population persistence in the Recovery Strategy and in the PHVA, is an important concept that is undefined. The PHVA's *VORTEX* model defines extinction as the absence of either sex. If persistence is the opposite of extinction, then a definition for the former can be constructed from the definition of the latter. Because persistence typically refers to presence over a period of time, we add a temporal component:

"A population of two or more frogs that includes at least one individual of each sex and exists for a given period of time. Note that a persisting population is not necessarily viable, but through reproduction it has the potential to exist beyond the life spans of the individuals in the population – see definition of "viable population""

This definition was placed in the Glossary. .

New Mexico Department of Game and Fish

This letter suggested no changes to the draft Plan: "The Department supports implementation of the final Recovery Plan based on the Draft and looks forward to assisting in recovery efforts for the Chiricahua leopard frog."

Response: No changes needed.

Salt River Project

E1: "SRP has three main concerns with the proposed Plan: 1) the Plan should recognize and discuss measures to minimize impacts to existing water rights holders due to recovery actions, 2) the Plan's emphasis on the adverse effects of dam operations on the leopard frog is unjustified, particularly given the inability of dam operators to prevent adverse impacts to the frog caused by nonnative fish populations introduced into the watershed many years ago by third parties; and 3) the criteria for determining compensatory mitigation, described in Appendix I, are susceptible of overly broad application and should be revised.

Response: These comments are elaborated upon later in SRP's letter – and are addressed below.

E2: SRP holds that the Plan should include recognition of private water rights and discuss protection mechanisms to minimize impacts to private water rights and operators of water management facilities. Most importantly, SRP finds that recommendations for removal of dams and/or proposals to reduce diversions would be in conflict with water rights and cause harm to the holders of those rights. The Team and the U.S. Fish and Wildlife Service should consider these potential impacts in formulating the timing and location of future recovery projects.

Response: In E3, specific excerpts from the text are provided by SRP where they think modifications are needed to address their concerns. The following text was also revised:

Page 54, 2nd full paragraph, 5th sentence: Revised as follows: "Education and outreach will complement these efforts by again building support and understanding of the recovery program, as well as developing conservation partnerships with landowners and managers, water rights holders and dam/reservoir operators, recreationists, ranchers, anglers, and others that use and enjoy public lands."

Page A-2, 3rd paragraph, first sentence: Revised as follows: "Currently, the greatest opportunities for ranchers and land or water managers to participate…"

Page A-10, 1st full paragraph, 6th sentence: Revised as follows: "If the land or water manager…"

Page A-26, 2nd line: Revised as follows: "Private property and water rights will be respected."

E3: In this comment, SRP provides specific suggestions for revised text to support their more general comment in E2. These are addressed here one by one:

Page 53, bottom of second paragraph: Consider including agreements with water holders.

Response: Revised to read: "…(e.g. agreements with landowners and water rights holders, abatement of…"

Page 76 (1.2.1): add "water managers".

Response: Revised to read: "… that can be used by land and water managers, ranchers, and others…"

Page 76 (1.2.2): Suggest revision: "Once developed, recommendations should be implemented on public lands (after consideration and protection of private water rights interests if appropriate), and in the case of willing private landowners or water rights holders on private lands."

Response: Revised as follows: "Once developed, recommendations should be implemented on public lands, and in the case of willing private landowners, on private lands. Private and tribal land and water rights will be respected."

Page 83 (2.3): add "On Federal and non-Federal lands, agreements with willing water rights holders, such as Safe Harbor Agreements or other agreements, may be needed to provide assurances that those rights are not economically harmed by presence of frogs or recovery actions."

Response. Safe Harbor Agreements cannot be implemented on Federal lands. The text was revised as follows: "Agreements with willing land or water rights holders, such as Safe Harbor Agreements or other agreements, may be needed to provide assurances that those rights are not economically impacted by presence of frogs or recovery actions."

Page 85 (4.3): same as Page 83 (2.3) above.

Response: Replaced current language with suggested language from previous comment.

Page 91 (8.1, 8.2): Similar comment – include water rights interests when developing partnerships.

Response: Inserted "water rights holders" after "landowners" in 8. In the text for 8.1, inserted "and water rights holders" after "Landowners" in second sentence. No changes needed to 8.2.

Page B-57 (Tonto NF bottom 2nd paragraph): Should describe the baseline conditions at Blue-Ridge-East Verde River water diversion (average of 9,000 af/yr, range of 0-15,000 af/yr), which is in the Upper East Verde River MA. Need coordination with SRP on recovery actions.

Response: At the bottom of the subject paragraph, added "Recovery implementation in this area will need to consider water management. Coordination with Salt River Project and other water users will be necessary when considering water needs for recovery efforts."

Page D-4 (3rd paragraph): Suggested revision: "If private landowners and/or water rights holders are willing to allow reestablishment on their lands or using their water, it will often be desirable to develop Safe Harbor Agreements or other such agreements prior to population establishment."

Response: Revised as suggested.

Page H-12 (1st bullet): Revise to read "…with willing landowners on private lands or water right holders on private or public lands…"

Response: Revised as suggested.

Page H-16 (1st paragraph): Where a valid water right exists, public land managers are not free to decide that a dam "no longer serves its useful purpose" and remove it. Suggest revising the 1st paragraph to read "Recovery Team members, land managers, and wildlife agencies should work with water resources users to evaluate dams and diversions (particularly springs) that are negatively affecting the extent and suitability of Chiricahua leopard frog habitat, or that provide stable, permanent water sources for non-native predators, to identify strategies to eliminate or reduce impacts. In particular, removal may be considered in coordination with and with approval of water rights holders when such facilities no longer serve their useful purpose and/or when they could feasibly be replaced by other, less environmentally damaging facilities capable or supplying water of equal or better quality compared to the facility proposed for removal."

Response: Adopted commenter's suggested text with minor revisions: "Recovery Team members, land managers, and wildlife agencies should work with water resources users to evaluate dams and diversions (particularly springs) that are negatively affecting the extent and suitability of Chiricahua leopard frog habitat, including those that provide stable, permanent water sources for non-native predators. Strategies to eliminate or reduce impacts to the frog should be developed. In particular, removal of dams and diversions may be considered in coordination with and with approval of water rights holders and land/facility owners when such facilities no longer serve their useful purpose and/or when they could feasibly be replaced by other, less environmentally damaging facilities capable or supplying water of equal or better quality compared to the facility proposed for removal."

Page H-16 (c): Consider discussing working with groundwater pumpers on private lands that could be influencing frog habitat.

Response: In the bolded part of part (c), removed "on public lands". At the end of the 2nd paragraph, added "The Recovery Team should attempt to work with groundwater pumpers on private lands, if possible, if private wells are adversely affecting Chiricahua leopard frog habitat."

E4: In this comment, SRP believes the plan should recognize that water facility operators often have no authority to prevent or control establishment of non-native sport fisheries, bullfrogs, etc. into reservoirs or other water facilities. The Plan needs to more thoroughly describe the influence of past and ongoing fisheries management on occupied and potential recovery habitats and what actions would need to be taken by agencies to promote and achieve recovery in the RUs and specific locations within MAs. SRP then goes to describe specific text where changes are recommended, pursuant to this comment:

Pages 36-37 (Dams and Reservoirs) and Page 50 (Water): Some non-native fisheries are sustained by stocking, and would not otherwise maintain themselves. Also, in some arid basins, the presence of dams and resulting altered hydrology may benefit the frog through flow maintenance and the creation of more habitat than what might otherwise be present. As a result, there may be opportunities for Recovery Team members to work with water managers to improve conditions for frogs.

Response: The discussion on page 50 simply states the Chiricahua leopard frog's biological needs and constraints, and is not the appropriate section to elaborate on the effects of dams or non-native fish stocking. As a result, no changes are needed on page 50. On page 37, the following was added to the first paragraph: "Creation of reservoirs is not the direct cause of the loss of Chiricahua leopard frog populations. However, the stable, deep water they provide is excellent habitat for sport fisheries, crayfish, and bullfrogs. A long history of State, Tribal, and Federal stocking programs, combined with "bait-bucket" introductions have rendered these aquatic sites largely unsuitable for leopard frogs. In some cases, such as high altitude lakes, if stocking ceased, non-native fish populations might disappear due to lack of reproduction. In those cases, there may be opportunities for restoration of native fish and frog populations."

Immediately before the last sentence at the end of the 2nd paragraph on page 37, added "In some cases, dams may have created more stable or perennial flows in downstream reaches, which were historically unsuitable for Chiricahua leopard frogs. However, these reaches now almost invariably support non-native predators."

Pages 77-78 (1.2.9): The Plan should recognize that actions to control deleterious fish and wildlife species are under control of State or Tribal wildlife agencies and coordination and permits are needed to implement those actions.

Response: Added at the end of the text in that section: "Control of non-native predators must be coordinated and permitted through appropriate State, Tribal, and Federal agencies."

Page B-4: SRP recommends adding language such as "stressors were summarized across broad geographic areas and there is likely high variation among individual sites. Thus for site

assessment and project evaluations, managers must use site or project specific information to determine impacts on frogs and their habitats."

Response: The purpose of the threat assessment is to evaluate threats broadly across RUs, and is not appropriate for site-specific or project-specific threat assessments. Added the following to the end of the text on page B-4: "Assessment of threats at specific recovery sites should be based on a site-specific analysis within the context of this broader threats assessment (see recovery actions 2.1 and 2.2)."

Page B-58, Page B-63 - Table B-10: SRP believes the contribution, source, and irreversibility of "Extraordinary Predation" caused by dams and reservoirs should be reevaluated in light of the past and ongoing sportfish stocking. SRP considers the impact of dam presence and operation on all three criteria to be "Low", the ability to control or manage non-native fish in many of the small reservoirs within the delineated MAs is technically feasible, but would require AGFD (or NM Game and Fish or Tribal agencies) to change policy and management direction (as discussed in section 1.2.10). Thus, dam operations have a much smaller influence on the fish assemblage than is presented in the Draft Plan. More discussion and information is needed on pages B-58 to B-61 that substantiates and explains the ratings in Table B-10, and qualifying language (B-4 comment) should be referenced.

Response: Page B-58 does not mention dams or reservoirs in regard to extraordinary predation (no changes needed there). In Table B-10, dams and reservoirs are shown as having "very high" contribution to extraordinary predation, "very high" irreversibility, and "very high" as a source of the threat. Going back to the definitions on page B-2, "very high" in regard to "contribution", means that the source (dams and reservoirs) has a very high contribution to the stress (extraordinary predation). Dams and reservoirs create the habitat suitable for large populations of non-native fishes and other predators. In unaltered systems (without the dams and reservoirs) often there is marginal or no habitat for many of these species. Reservoir populations of these species often serve as source populations from which dispersal occurs, causing spread and invasion of other nearby habitats. Many reservoirs are also popular recreation sites, and even without stocking by State, Federal, or Tribal agencies, the public will introduce fish into these systems or they will invade from adjacent aquatic systems. We attempted to capture the influence recreation has on extraordinary predation on page B-64. There is no source of stress that corresponds to sport fisheries stocking, but that should be captured in the "recreation" source of stress. In regard to irreversibility, the Recovery Team believed it was essentially impossible to remove dams and reservoirs, hence the "very high" ranking. The model's algorithms produce the "source" and "combined rank" rankings. In regard to the comment that "More discussion and information is needed on pages B-58 to B-61 that substantiates and explains the ratings in Table B-10, and qualifying language (B-4 comment) should be referenced", we refer the reader to The Nature Conservancy's "The Five-S Framework for Site Conservation: A Practitioner's Handbook for Site Conservation Planning" for more information about the process that produced the threat assessment results (see page B-3). No revisions needed.

E5: Page I-1 (1st paragraph) and I-13: SRP believes that the recommendations to apply the conservation measures broadly across MAs prior to identification of site specific recovery areas

and introduction of frogs into currently unoccupied habitats is not warranted and without legal basis.

Response: In the first paragraph, page I-1, we state: "The following conservation measures should be incorporated into all projects that may affect suitable frog habitats, sites selected for habitat restoration or creation, and movement corridors among sites within MAs."
Hence, the conservation measures do not apply broadly to MAs, but rather are focused on specific areas with the greatest potential for frog recovery. These specific sites are likely to be a very small percentage of the total land area in each MA (aquatic habitats are scarce, particularly those that are suitable for Chiricahua leopard frogs). Consistent with the rest of the recovery plan, these conservation measures are recommendations (not legal requirements), but it is hoped that land managers and project proponents would adopt these measures when developing project proposals. No revisions needed.

E6. The Draft Plan erroneously suggests that compensation or mitigation are required for any project proposed within MAs, regardless of whether such compensation or mitigation is necessary to avoid a violation of the Endangered Species Act. The team should consider and describe a more refined approach to the evaluation of project impacts to frog recovery. Revisions and clarification are needed in this section and on page I-13 (and possibly other sections in Appendix I) so that that the Plan's recommendations for project impact compensation conform to the ESA, implementing regulations, and relevant case law.

Response: In regard to the comment that the conservation measures are "required", see our response to E5. Nowhere in Appendix I does it say that the measures are required. The title of the Appendix is "Recommended Conservation Measures for Projects Affecting Frogs". The conservation measures were based on measures developed in actual projects that went through the section 7 consultation process for the frog and other species, as well as literature and experience with related species (some of that literature is cited in this Appendix). The Appendix is not novel; the format and content is consistent with measures developed for the desert tortoise (Desert Tortoise Compensation Team 1991), the flat-tailed horned lizard (pages 58-64 of Flat-tailed Horned Lizard Interagency Coordinating Committee 2003), and the relict leopard frog (Appendix 3 of Relict Leopard Frog Conservation Team 2005). Recommending conservation measures to minimize project impacts to a listed species and its habitat is consistent with the purposes and policies of the Endangered Species Act, as described in section 2(b) and (c) of the Act, as well as section 7. Providing these conservation measures will also assist Federal agencies in meeting their responsibilities to conserve listed species under section 7(a)(1)(A) of the Act. No revisions needed.

E7: Page I-13. In regard to groundwater pumping, impoundments, and surface water diversions, recommendations should be applied where specific restoration/creation sites have been identified and can be specifically evaluated. The recovery sites selection criteria should consider and eliminate potential conflicts with existing and known future water diversions and uses.

Response: See response to comment E5. The recommendations for conservation measures only apply to projects that may affect suitable frog habitats, sites selected for habitat restoration or creation, and movement corridors among sites within MAs. In regard to the comment about site

selection criteria, the following sentence was inserted at the end of the first (incomplete) paragraph on page D-4 of Appendix D: "Potential conflicts with water rights and existing or known future water diversions and uses should be minimized."

E8: page 24, 2nd paragraph: Consider discussing that habitat complexity likely influences the frog's ability to survive in the presence of predatory native fish.

Response: Added the following to the end of the 1st complete paragraph: "Chiricahua leopard frogs are also more likely to persist with predators in sites exhibiting habitat complexity."

E9: page 40 (1st paragraph): We agree with statements concerning influence of altered hydrology as the underlying cause of saltcedar presence; however, the Team should review recent literature and consider the beneficial effects to removal in some small spring systems. See: Kennedy *et al.* 2005. Eradication of invasive *Tamarix ramosissima* along a desert stream increases native fish density. Ecological Applications 15(6):2072-2083.

Response: Control of saltcedar in some situations is recommended in the Conservation Assessment and Strategy for the relict leopard frog. Revised the 1st complete sentence on page 40 as follows: "Removing saltcedar, and potentially replacing it with native species, is likely to have few benefits for leopard frogs, but may have application at some sites (see Kennedy *et al.* 2005, Relict Leopard Frog Conservation Team 2005)." These two citations were added to the Literature Cited section.

E10: Page B-55: In the map, "Upper Verde River" should be "Upper East Verde River".

Response: The name of the MA as shown on the map and as listed on page B-60 is "Upper Verde River MA". However, it is essentially the upper East Verde River (including Ellison Creek), not the Upper Verde River. The name of the MA on the map and on page B-60 was changed to "Upper East Verde MA".

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Chiricahua leopard frog illustration by Dennis Caldwell